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REPORT OF THE COMMITTEE "TO STUDY THE HEALTH HAZARDS IN ASBESTOS INDUSTRY" CONSTITUTED BY THE DGTD PANEL ON ASBESTOS PRODUCTS INDUSTRY

PREFACE

In pursuance of the decision taken by the Panel on Asbestos Products Industry, constituted by the Government vide its Resolution No. 6-14/81-Cem. dated 22.8.1981, during its sixth meeting held at Madras on 12th July 1983, Department of Environment was requested to head the Committee formed to "Study Health Hazards in Asbestos Industry".

The terms of reference assigned to this Committee were :

- To formulate a proposal for the study of the health problems associated with inhalation of asbestos fibre at the workplace or in the general environment.
- To examine the adequacy or otherwise of existing legislative provisions for protecting occupationally exposed workers from risk of asbestos induced maladies.
- To make other recommendations as appropriate in regard to health and safety in the Asbestos Products Industry.

The Chairmanship of the above mentioned Committee was entrusted to me and it consisted of members specially drawn from research organisations, Government regulatory agencies, the industry and independent experts in the field. The list of the Committee members is attached.

The Committee met for the first time on 25th February 1984 and decided that the terms of reference, being wide in their content, could be appropriately resolved into the various areas of study, which in turn should be alloted to two study teams for detailed study and analysis. The study teams formed & their areas of study are detailed below :

- Study Team 'A', under the Chairmanship of Dr. B. B. Chatterjee, was asked to study health problems associated with inhalation of asbestos fibre dust at workplace or in the general environment, covering all medical aspects including medical surveillance and diagnostic criteria.
- Study Team 'B', under the Chairmanship of Dr.G.G. Davay, was asked to:
  - Examine the adequacy or otherwise of existing legislative provisions for protecting occupationally exposed workers from the risk of asbestos induced maladies. The Team were to study the Factories Act, Model Rules under the Factories Act, Model Rule 123A/other guidelines issued by the Government of India, the Indian Mines Act and the Draft National Regulations for Asbestos formulated by the Asbestos Information Centre (AIC). The consensus of opinion was that the National Regulations should be exhaustive and specific which are applicable, as a standard, in all the States in India ;
  - Cover in depth all aspects of Workmen's Compensation Act, ESI Act and Insurance cover. The study was to cover the agency for deciding claims of compensation and level of compensation and the policy of nationalized insurance companies regarding insurance cover for temporary and permanent disablement arising from exposure to asbestos dust.

Both these Study Teams met independently several times and collected important data by visiting mines, factories at various locations and/or by literature search for scientific works on the subject and study of regulations and practices of various countries and international bodies, like, the ILO.

The Committee reviewed the progress of work of the two Study Teams during intermediate meetings with useful exchange of technical data. The reports of both the Study Teams have now been received and after scrutiny by the Committee are placed on record and appended to this report

I would like to thank both the Teams for the great effort in generating this important and useful document and also the members of this Committee for their valuable guidance from time to time

I would also like to place on record my sincere appreciation for the untiring efforts put in by Brig D.B. Kapoor, Member Secretary of the Committee, but for whose assistance the report could not have been completed within the stipulated time.

I would finally thank the Chairman of the Panel on Asbestos Products Industry for providing me this opportunity to deal with such an important subject. I believe that the dedicated expertise of all the members connected with this report is amply revealed by the qualitative technical evaluation contained in the document.

I have no doubt that this report will form a useful base document to evolve strategy and plans for the control and elimination of risks in the asbestos industry and other such industries dealing with toxic materials suspected of long term health effects.

Sd.
(D.K. BISWAS)
Chairman of the Committee

New Delhi
9 July 1985.

LIST OF MEMBERS OF THE COMMITTEE "TO STUDY HEALTH HAZARDS IN ASBESTOS INDUSTRY"

1.	Mr. D.K. Biswas Director, Department of Environment, Government of India, Bikaner House, Shah Jahan Road, New Delhi-110 011	Chairman
2.	Dr. V.P. Gupta Director (Research), Central Labour Institute, Eastern Express Highway, Sion, Bombay-400 022.	Member
3.	Dr. B.B. Chatterjee Director, National Institute of Occupational Health, Maghani Nagar, Ahmedabad-380 016.	Member
4.	Dr. G.K. Pandey Principal Scientific Officer, Department of Environment, Government of India, Bikaner House, Shah Jahan Road, New Delhi-110 011.	Member
5.	Dr. G.G. Davay Ex Medical Inspector of Factories Government of Maharashtra, 7/72, Varma Nagar Old Nagardas Road, Andheri (East), Bombay-400 069.	Member
6.	Mr. G.S. Ichhpurani DDG of Mines Safety, Southern Zone, Hyderabad	Member
7.	Dr. S.K. Dave Asst. Director, National Institute of Occupational Health, Maghani Nagar, Ahmedabad-380 016.	Member
8.	Mr. B.K. Sharan Director, Mines Safety, Directorate General of Mines Safety, Dhanbad.	Member

9. Mr. N. Venkataraman — Member
Managing Director,
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10. Mr. J.B. Amin — Member
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11. Mr. V. Pattabhi — Member
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12. Dr. S.P. Vivek Chandra Rao — Member
Medical Officer,
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13. Dr. P.K. Sishodiya — Member
Hyderabad Asbestos Cement
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Ballabgarh,
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14. Brig. D.B. Kapoor — Member Secretary
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SUMMARY OF OBSERVATIONS AND RECOMMENDATIONS

Observations

1. **Main observations are :**

1.1 Uncontrolled asbestos usage has been the cause of heavy and prolonged exposures to workers. Such exposures to asbestos dust may result in asbestosis, lung cancer and mesothelioma. (Para 9 of Report by Study Team 'A').

1.2 These diseases have long latent periods, making it difficult to relate exposure to the prevalence of disease at any given time. (Para 10 of Report by Study Team 'A').

1.3 There are some reported cases of low exposures in the past that resulted in no appreciable increases in risk. A report on the evaluation of risk to miners in Canada on current levels of exposures (50 fibre years) is estimated to have had no unacceptable risks. (Para 11 of Report by Study Team 'A'). Such information enables this Committee to recommend the use of asbestos in such places where it can be used under controlled and regulated conditions so that the benefits of this material continue to be exploited without any undue risks to the workers.

1.4 The latest scientific thinking favours the controlled use of not only asbestos but also other inorganic fibrous materials. (Para 13 of Report by Study Team 'A').

Recommendations

2. **General Environment**

2.1 Various studies reveal that asbestos in general environment has not been found to cause any detectable increase in risk to the people at large. (Para 21 of Report by Study Team 'A'). It is, however, prudent to control all asbestos realeases into environment as per international practices. (Para 21 of Report by Study Team 'A')

2.2 At this point of time, studies on ingestion of asbestos fibres through drinking water have been attended with negative results. (Para 22 of Report by Study Team 'A').

2.3 State Pollution Control Boards should make emission standards for the control of asbestos fibre dust in the general environment. (Para 16.10 of Report by Study Team 'B').

3. **Legislative Regulations.**

3.1 **Factory Acts & Rules**

3.1.1 Framing of rules according to the Schedule XIV and Model Rule 123A by the concerned States is an urgent requirement. (Para 16.2 of Report by Study Team 'B').

3.1.2 All operations and places where asbestos fibre is used should be brought under the purview of the Factories Act and Rules, irrespective of the size of the workforce or usage of electric power. (Para 16.8 of Report by Study Team 'B').

3.1.3 Every process and equipment related to the milling of asbestos ore and processing of asbestos fibre should be studied for its potential to create air-borne dust. In case any process/equipment releases dust that cannot be controlled to the desired limit by engineering control methods, such process/equipment should be prohibited. (Para 16.5 of Report by Study Team 'B').

3.1.4 Current prescribed level of 2f/cc as specified in Model Rule 123A is considered adequate at the present time. Membrane Filter Technique (MFT) should be used for the measurement of the air-borne asbestos fibre dust. (Para 16.1 of Report by Study Team 'B').

3.1.5 Measurement of fibre dust levels is a complex subject and efforts should be made to obtain uniformity within industry and regulatory agencies (Para 16.3 of Report by Study Team 'B').

3.1.6 Personal protective equipment should not be considered a permanent solution in place of preventive engineering control measures. At best, this should be a contingency measure. (Para 16.4 of Report by Study Team 'B').

3.1.7 Equipment used in the processing of asbestos should carry a certificate from the manufacturer that during normal usage as recommended, the equipment will not release fibre dust that will result in any workman being exposed to dust levels higher than the prescribed limit. (Para 16.6 of Report by Study Team 'B').

3.2 **Mines Act; Regulations & Rules Thereunder.**

3.2.1 The regulations and rules made under the Mines Act 1952 need to be modified to bring them upto the International Standards for the control of asbestos fibre dust during mining, handling and milling of the ore.

3.2.2 Where applicable, the rules under the Mines Act should be modified so as to include the relevant provisions of Schedule XIV and Model Rule 123A made under the Factories Act so far as they relate to asbestos fibre dust control.

3.2.3 Asbestosis; lung cancer and mesothelioma when they are caused by asbestos should be notified as occupational diseases under the Mines Act.

3.2.4 Specialised trained manpower and equipment are to be provided to effectively monitor the environmental exposures in mines and medical surveillance system of the mine workers (Para 16.9 of Report by Study Team 'B').

3.3 **Licencing.**

For licencing/registration of new units, specific requirements of dust control to be met by them should be listed out by the competent authority. Licence should be issued by the competent authority only after satisfying itself that such requirements have alreadv been included in the project. (Para 16.8 of Report by Study Team 'B').

4. **Small Scale Industry.**

Management and control of asbestos dust in the small scale sector of the industry need to be tackled on priority basis. Major recommendations in this regard are :

— *Financial* : Subsidy should be given for the purchase of equipment needed for the control of dust, personal sampling etc. Capital assets under this category should not be counted for the capital investment clause which determines classification for small scale sector.

— *Engineering* : A technical cell in D.I.C. or other concerned agency should be directed to pool the technology for the suppression/control of asbestos dust and to help the Small Scale Industry to select and install appropriate equipment.

— *Measurement and Heatlh Control* : The Small Scale Industry should be encouraged to pool their resources and establish a centralised dust counting centre, as also a health surveillance centre under the supervision of a competent qualified person.

— *Education* : Employees in this industry should be made aware of the need for strict implementation of the asbestos regulations and the health hazards that might arise due to occupational exposure to asbestos.

(Para 16.7 of Report by Study Team 'B').

5. **Compliance of Regulations.**

5.1 Packing of raw asbestos fibre should be in impermeable bags and should be handled as unitised loads as far as it is practicable. ISI may be requested to bring out the Code of Practice for packing, handling, transportation and use of asbestos fibre. (Para 16.11 of Report by Study Team 'B').

5.2 Effective steps to implement the Rules must be taken by providing all facilities to the state regulatory agencies. These include dust monitoring equipment and specialised trained man-power in order to produce accurate and reproducible results. (Para 16.3 of Report by Study Team 'B').

5.3 The industry should periodically monitor dust levels to ensure the effectiveness of the engineering controls. (Para 9.2 of Report by Study Team 'B').

5.4 Government should be liberal in allowing the import of equipment required for the use in dust monitoring & medical surveillance. (Para 16.13 of Report by Study Team 'B').

6. **Medical Surveillance.**

6.1 All the workers likely to be exposed to asbestos fibres should be covered by a well defined medical surveillance plan with no cost to the employee. (Para 27.2 of Report by Study Team 'A').

6.2 Health education of workers is an important object of medical surveillance programme. (Para 28.1.2 of Report by Study Team 'A').

6.3 Frequency of periodical medical examination should take into account age, service of employee and his exposure profile which includes his exposure level in relation to action level. (Para 29.3 of Report by Study Team 'A').

6.4 Medical records along with periodic exposure profiles should be maintained for 40 years after employment or 10 years after cessation of employment. (Para 32.2 of Report by Study Team 'A').

7. **Compensation.**

7.1 The employees covered under the ESI Act should also be eligible for compensation after cessation of ESI coverage, as is the case in Workmen's Compensation Act. (Para 16.12 of Report by Study Team 'B'). Employees not covered under the ESI Act should be covered under general insurance, at no cost to them. (Para 14.6 of Report by Study Team 'B').

7.2 Clear criteria for the diagnosis of asbestos related diseases should be specified and should be uniformly followed. (Para 14.2 of Report by Study Team 'B'). Criteria for diagnosis for asbestosis is included in this report for the purpose of determining eligibility for compensa-tion. (Para 24.1.6 of Report bo Study Team 'A'). Criteria for confirming asbestos as caus-ative factor for lung cancer and mesothelioma is also included in this report for the purpose of determining eligibility for compensation. (Paras 25.7 and 26.8 of Report by Study Team 'A)'.

7.3 The Committee recognises the need to designate an agency that possesses specialised training, expertise, competence and facilities to decide the cases entitled to compensation arising out of asbestos-related diseases. (Para 16.12 of Report by Study Team 'B').

7.4 Regional medical panels should be constituted to act as referal bodies in case of asbestos-related diseases to determine eligibility for compensation. (Para 34 of Report by Study Team 'A').

7.5 Panel should have specialists, preferably with knowledge of asbestos-related diseases. (Para 34 of Report by Study Team 'A').

8 **National Standards/Codes of Practice.**

ISI may be requested to expedite formulation of:

- Standard for the measurement of airborne fibrous dust.
- Code of practice for the packing, handling transportation, and use of asbestos in the factory, mine and other places.
- Code of practice for the use of asbestos containing products.
- Code of practice for disposal of asbestos waste materials, including tailings.

(Para 16.14 of Report by Study Team 'B').

FINAL REPORT OF THE STUDY TEAM 'A' FORMED UNDER THE AEGIS OF THE COMMITTEE "TO STUDY THE HEALTH HAZARDS IN THE ASBESTOS INDUSTRY", CONSTITUTED BY THE DGTD PANEL ON ASBESTOS PRODUCTS INDUSTRY

PREAMBLE

In pursuance of the decision taken by the DGTD Panel on Asbestos Products Industry to constitute a Committe to "Study the Health Hazards in Asbestos Industry", a Study Team designated as Study Team 'A' was formed and was assigned the tasks as appear in its terms of reference appended hereafter.

The Chairmanship of this Study Team was entrusted to me and I, co-opted members from Governmental agencies, Industry and the Asbestos Information Centre, with sufficient expertise and resources to contribute to the study and review all aspects connected with the health problems of asbestos exposure and provide suitable recommendations for the management of the major issues.

The Team was conscious of the absence of suitable epidemiological studies in this country on asbestos related problems. Sufficient expertise and manpower required for the evaluation of the workplaces and timely and accurate diagnosis of asbestos-related diseases do not seem to be available to meet the requirements in the country. Exchange of experiences in this field between the Government agencies and the industry alongwith a consideration of the existing facilities and practices of the regulatory bodies in the developed countries, where extensive work has been done on this problem, helped the Study Team to identify areas of consensus which have been recorded. For achieving this, we have utilised publications by the ILO, Health & Safety Executive (UK) reports, NIOSH (USA) reports and published articles by eminent scientists in the field.

I hope that this report will be helpful in bringing about a uniformity of approach, practicable management and reasonable protection of employees at potential risk from exposure to airborne asbestos dust at their workplaces.

We believe that we have to learn to live with asbestos; a substance that is going to be with us for a long time to come. In so doing,we might also learn to beneficially use other materials of toxic nature while deriving social benefits accruing from their use, at the same time, containing their hazards adequately.

The co-operation and contribution of all the members of the Study Team made it possible for me to bring out this report and I sincerely wish to thank them. I would particularly like to thank Mr. D.K. Biswas of the Department of Environment for providing me with this opportunity to lead such a competent team of experts.

Sd.
(Dr. B.B. CHATTERJEE)
CHAIRMAN OF STUDY TEAM 'A'.

27th June 1985.

FINAL REPORT OF THE STUDY TEAM 'A' FORMED UNDER THE AEGIS OF THE COMMITTEE "TO STUDY THE HEALTH HAZARDS IN ASBESTOS INDUSTRY", CONSTITUTED BY THE DGTD PANEL ON ASBESTOS PRODUCTS INDUSTRY.

Terms of Reference

1 The terms of reference assigned to the Study Team 'A' were to :

(a) Study health problems associated with inhalation of asbestos fibre dust at workplace or in the general environment, covering all medical aspects including medical 'surveillance and diagnostic criteria. In case the Team felt that it was not in a position to study in detail the problem of general environment, it could prepare an 'approach paper', identifying areas of study by other agencies, giving recommendations thereof.

(b) Cover in depth all aspects of workmens' compensation Act, ESI Act, and Insurance cover. The Study should cover the agency for deciding claims of compensation and level of compensation and the policy of nationalised insurance companies regarding insurance cover for temporary and permanent disablement arising from exposure to asbestos dust.

2 Under the second term of reference, the Team considered that the following subjects were in the purview of the Study Team 'B' :

(a) The agency for deciding compensation.

(b) The level of compensation.

(c) Policy of the nationalised insurance companies regarding insurance cover for disablement arising from occupational exposure to asbestos dust.

Thus, the Study Team 'A' decided that it may make recommendations only on the following aspects under the second term of reference :

— Composition of the panel to decide the eligibility for compensation.

— Criteria for diagnosis of occupational asbestos-related diseases for the purpose of compensation.

Study Team 'A' and its Action Plan

3 The Study Team 'A', comprised as under, was constituted by the Committee "To study Health Hazards in Asbestos Industry", during its first meeting held on 25th February, 1984, in the Department of Environment, Bikaner House, New Delhi :

(a) Dr. B.B. Chatterjee	Chairman
(b) Dr. G.G. Davay	Member
(c) Dr. V.P. Gupta	Member
(d) Dr. S.K. Dave	Member
(e) Dr G K Pandey	Member
(f) Mr N. Venkataraman	Member
(g) Mr J.B. Amin	Member
(h) Mr V. Pattabhi	Member
(i) Dr S P. Vivek Chandra Rao	Member
(k) Brig D.B. Kapoor	Member

4. The Study Team met at Ahmedabad on 21.7.1984 and at New Delhi on 31.1.1985. During these meetings, it was decided to review the scientific knowledge available on the subject both in India and abroad. In the Study Team, representation was given to the regulatory agencies and the industry which were in a position to contribute relevant technical information. Various technical papers, such as, the reports of the Advisory Committee on Asbestos constituted by the Health and Safety Executive, UK, & the Ontario Royal Commission "On matters of health and safety, arising from the use of asbestos", review and recommendations of the National Institute for Occupational Safety and Health (NIOSH). U.S.A. on workplace exposures to asbestos, papers published by the Asbestos Institute, Montreal, Environmental Protection Agency, USA and other relevant literature published by eminent physicians and scientists have been taken into account by the Study Team in formulating its observations and drawing up recommendations.

Asbestos and Health

5. Asbestos, a generic term covering fibrous silicate minerals, is limited in commercial use to actinolite, amosite, anthophylite, chrysotile, crocidolite, tremolite and mixtures thereof.

6. India uses chrysotile the most, tremolite to some extent and crocidolite to a much lesser extent. In India, tremolite is principally mined in Rajasthan and Karnataka. Chrysotile is presently mined only in Andhra Pradesh (Cuddaph).

7. While literature on the subject mentions about the usage of asbestos in over 3000 products, the Study Team has no information as to how many products are actually manufactured in India. Most significant non-industrial end use is in asbestos cement products and vinyl tiles whereas industrial uses include insulation products, textiles, friction materials such as brake linings/clutch facings and gasketing materials like compressed asbestos fibre (CAF) jointings and beater addition (BTA) jointings etc.

8. Asbestos-related health issue was first identified in the U.K. as a form of pneumoconiosis termed asbestosis, then lung cancer was identified as an occupational risk related to asbestos. Mesothelioma has been shown to be causally related to exposure to asbestos dust since 1960 ** It was then thought that 'asbestos & health' problem was limited to only factories. It was later found that workers employed as insulators in the industry and building trades and in ship building formed the highest risk prone groups where they used friable asbestos products outside factory settings. Several of these applications with high health risks are not prevalent in India, for example :—

(a) Insulating the buildings, using sprayed asbestos insulation.

(b) Friable insulation panels for building construction.

It is conceivable that what little ship building industry we have, might have used some low density asbestos insulation in the past. Such facts need to be obtained.

9. There is little doubt that uncontrolled asbestos usage in the past resulted in prolonged and usually heavy asbestos dust exposures to workers. The severity of exposure, obviously, is related to the choice adopted for processing of fibres and the level of precautions taken.

10. There is a consensus about the long latent periods of asbestos related diseases—Asbestosis generally taking over 10 years after exposure to manifest; Lung Cancer over 15 to 20 years & Mesothelioma over 30-40 years. This phenomenon makes it difficult to relate the exposures with confidence to the current prevalence of the diseases. The diseases seen today are the results of conditions generally prevalent in the pre-regulation era.

** Wagner J.C. Sleggs, C.A. & Marchand, P. (1960) Brit. J. Industr. Med., 17, 260 (Final Report of the Advisory Committee (UK)—Vol. II., Para 92, Page 21.)

11. Due to the same reasons, it is also not possible to accurately predict the level of these diseases in the years to come when the effects of regulated asbestos usage will be known. However, some statistical predictions indicate that controlled use of asbestos should not give rise to any unreasonable risk. Based on evaluation of J.C. McDonalds' Study of miners, exposure of 1 f/cc for 50 years should not cause any detectable Asbestosis and the risk of lung cancer is expected to be equivalent to smoking 3 cigarettes per month.**

12. The necessary precautions that have already been taken in the Western countries have virtually eliminated gross Asbestosis that led to early deaths in the past. For example, no deaths from Asbestosis have been observed in the men and women who have been studied in an asbestos textile factory in Rochdale (UK) who were first employed after 1950***

13. It is also to be noted that the latest scientific thinking favours controlled use of all inorganic fibrous materials, not just asbestos. This precaution is necessitated by the fact that several fibrous inorganic substances have also proved to be carcinogenic in experimental animals. These have not been sufficiently studied, nor have they been, in some cases, in use long enough to evaluate their epidemiological long-term effects.

14. There are countries that are formulating regulations to cover all fibrous materials usage. In this context, the ILO has prepared a general Code of Practice—"Occupational exposure to airborne substances harmful to health"; 1980 (ISBN-92-2-102442-3).

Indian Studies

15. Only some cross sectional studies of certain factories in India have been carried out, which are exploratory in nature. They served the purpose of bringing awareness in the industry and persuading all concerned to take effective measures. We have no national data base on which to make an assessment of the impact of asbestos related problems. In the same way, we cannot, at this time, decide the exposure limits related to our settings. Under these circumstances, it is prudent to accept the lessons drawn from extensive work that has been done in the developed countries and adopt the regulations they have formulated which will perhaps result in more than adequate protection.

Limitations of the Present State-of-Art

16. The Study Team recognises the fact that the dust measurement by Membrane Filter Technique (MFT) and phase contrast microscopy represent the best current state-of-art that can be routinely used by the industry.

17. There is no pathognomic feature specific for asbestos related diseases. An individual diagnosis has to be based essentially on occupational history of asbestos exposure.

General Environment

18. The inclusion of the problem of the presence of asbestos in the general environment in the terms of reference was discussed by the members of the Study Team 'A'.

19. Asbestos is ubiquitous and is found in the water, soil and air due to natural geographical erosions. Industrial activity & technical use have added to these levels significantly, more so near the mines, manufacturing sites and the waste dumps.

** McDonald J.C. and Liddel, F.D.K.—"Mortality in Canadian miners and millers exposed to chrysotile" - Final Report of the Advisory Committee (UK), Vol. II. Para 202, Page 40.

*** Report by Richard Doll & Julian Peto to Health & Safety Commission, U.K.—"Asbestos—Effects on health of exposures to asbestos" (Page 31, Para 2).

20. In isolated instances, problems may have arisen in the vicinities of asbestos mines, city dumps or discarded building materials and in the neighbourhood of industries using large quantity of asbestos and disposing their solid waste carelessly. Barring a few older references to the occurrence of environmental mesothelioma amongst population in the neighbourhood of an asbestos mine in South Africa, there is no evidence of similar problems elsewhere in the world.

21. Information gathered from various studies made in developed countries reveal that asbestos in the general environment has not been found to cause any detectable increase in risk to the general public. However, it is prudent to control the release of asbestos into the environment particularly in the air. Adherence to international regulations in the disposal of solid wastes and stack emissions is essential. It is also a good practice to plan for maximum recycling of asbestos wastes.

22. A number of studies on ingestion of asbestos fibres with water or beverages have been conducted in the developed countries and been attended with negative results.

23. Further, the approaches for quantifying population exposures to asbestos from the general environment and relating them to diseases amongst the members of the population are so difficult that the Study Team members felt that they were not equipped to make any pronouncements on the subject. It was also noted that there has been no indigenous experience on studies of this nature. The Study Team 'A', therefore, recommends that the problems of asbestos in the ambient environment be specially studied by a team of scientists under the guidance of the Department of Environment itself. This team should also include in its field of study the health problems relating to other naturally occuring non-asbestos fibrous minerals, such as, the zeolites, the abundance of certain varieties of which in the soil has been reported to have given rise to mesothelial tumors in the population, heretofore thought to be specifically associated with asbestos.

Criteria for Diagnosis

24. Asbestosis

Asbestosis is a form of pneumoconiosis, characterised by diffuse fibrosis of lung parenchyma, as a result of exposure to respirable airborne asbestos dust, for a long period. It is a non-infectious, non-malignant disease. It is often associated with fibrosis of pleura. The fibrosis is irreversible and the process of fibrosis may or may not progress even after exposure has ceased.

Asbestosis is a dose dependent disease. The time between first occupational exposure to asbestos dust and establishing diagnosis of Asbestosis is usually above 10 years.

24.1 Criteria for Dignosis

24.1.1 Exposure History

There should be an evidence of substantial occupational exposure to asbestos dust.

24.1.2 Clinical Features

Both signs and symptoms of Asbestosis are those of diffuse interst.tial pulmonary fibrosis, and hence these are not specific diagnostic features.

24.1.2.1 Symptom

24.1.2.1.1. Breathlessness

Progressive breathlessness is the main but a non-specific symptom of Asbestosis. Initially, breathlessness occurs on exertion. As breathlessness is observed in various systemic disorders, all possible causes must by excluded before a provisional diagnosis of Asbestosis is made.

24.1.2.1.2 **Dry cough & chest pain.**

Again, these symptoms are non-specific, infrequent and are likely to occur late in the course of the disease. Hence, these symptoms are of little diagnostic significance.

24.1.2.2 **Signs.**

24.1.2.2.1 **Crepitations.**

The earliest clinical sign of Asbestosis is the presence of persistent bilateral basal and/or infra axillary end inspiratory crepitations. Even though they are bilateral, they are not necessarily equal on both sides, But, this sign too is common to many forms of interstitial fibrosis; hence, not specific for diagnosis of Asbestosis.

However, when not accounted for by any other cause and when heard on atleast two occasions a few months apart, given a history of exposure and radiological evidence of dust disease, they do provide valuable confirmation of the diagnosis.

Further, this is an important sign as it often precedes abnormalities in the chest X-ray & lung function tests.

24.1.2.2.2 **Clubbing of Fingers.**

Finger clubbing, a symptom of chronic cardio respiratory ailments is of relatively rare occurrence in Asbestosis. It develops slowly and may be observed in the late stages of Asbestosis. A rapidly developing finger clubbing, particularly if painful, in a person with Asbestosis suggests supervention of Lung Cancer.

24 1.3 **Radiological Features.**

24.1.3.1 Basal diffuse interstitial fibrosis is the characteristic change recorded in Asbestosis. The change is more often bilateral. The shadows described are irregular. reticular or linear.

24.1.3.2 For diagnosing Asbestosis and also for comparison of films, a postero-anterior chest radiograph of good technical quality and of full size should be taken. It should include the thoracic inlet and both castophrenic angles, taken in deep inspiration, so that diaphragm lies below the fifth rib anteriorly and the tenth rib posteriorly.

24.1 3.3 The parenchymal changes on the radiograph are classified using the ILO International Classification of Radiographs of Pneumoconiosis (1980). Under this system, the irregular or linear shadows are described as follows :

's' type shadows—width upto 1.5mm.
't' type shadows—width over 1.5mm and under 3 mm.
'u' type shadows—width over 3mm and upto 10mm.

The changes may be of such profusion so as to obscure the normally clear margins of the bronchovascular structures. Small regular opacities (p q r) may also be present. In advanced cases of Asbestosis the sharpness of cardiac and diaphragmatic borders may be obscured.

24.1.3.4 Pleural changes like pleural plagues or transient pleural effusion or pleural thickening are usually the radiological indicators of asbestos exposure but not of the disease. These changes need not be associated with parenchymal fibrosis. More often these changes are bilateral.

24.1.3.5 Other causes of similar radiological changes must be carefully excluded prior to making the diagnosis of Asbestosis. This is more important in the early stages of the disease when the radiological changes are slight.

24.1.3.6 Where possible, comparison of the most recent chest x-ray film with earlier films of good quality is highly desirable.

24.1.4 **Lung Function Abnormalities.**

The characteristic abnormalities in Asbestosis are those of restrictive lung disease. However, charateristics of both restrictive and obstructive lung changes are noted in smokers, occupationally exposed to Asbestos.

24.1.4.1 Spirometry recordings, ie, FVC, FEV_1 and FEV_1/FVC percentage should be recorded periodically. A comparison of periodic lung function tests conducted over a number of years is of much greater value than a single observation compared to the standard predicted values.

However, in the absence of pre-employment or previously measured lung function values, predicted values are considered for comparison.** In assessing the results, allowance should be made for age, sex, height, ethnic differences and the effects of smoking habits.

24.1.4.2 While a restrictive pattern is consistent with the diagnosis of Asbestosis, it is not specific to this disease.

24.1.4.3 More sophisticated measurements in the assessment of restrictive lung diseases, like, measurement of transfer factor and lung compliance, reduced rate of lower lobe emptying, are diagnostically helpful as further evidence, but are not essential for the routine medical surveillance of asbestos exposed workers.

24.1.5 **Other Investigations (non-essential).**

24.1.5.1 **Asbestos Bodies.**

The presence of ferruginous (asbestos) bodies in the sputum is only an evidence of exposure to asbestos dust but are not diagnostic of Asbestosis.

24.1.5.2 **Biopsy.**

Biopsy is rarely a justified procedure for the diagnosis of Asbestosis. It is only justified when an asbestos exposed worker is suspected to be suffering from a curable ung disorder or a thoracic operation is conducted on the worker for any reason.

24.1.6 **Diagnostic Categorization.**

24.1.6.1 The main diagnostic criteria for Asbestosis are as given below :

(a) History of significant exposure for at least 10 years.

(b) Radiological features consistent with basal fibrosis (category 1/O or above, ILO (1980) Classification of Radiographs on Pneumoconiosis).

(c) Characteristic bilateral infra auxillary or basal crepitations.

(d) Lung function changes consistent with at least some feature of restrictive syndrome.

24.1.6.2 The presence of all the above mentioned four criteria would suggest "Asbestosis".

24.1.6.3 Presence of criteria (a) and (b), mentioned above, alongwith either (c) or (d) would suggest "Probable Asbestosis".

24.1.6.4 It must be needless to repeat that other clinical conditions giving rise to similar radiological and lung functions should be excluded.

** Normal Standards of Pulmonary Function-Tests for Healthy Indian Men 15-40 years old, Comparison of Different Regression Equations. (Predicted Formulae)" by S.K Jain & T.J. Ramiah, Ind. Jour. Med. Res. 57, 8 August, 1969.

Age, Height & Body Weight Determinants of Ventilatory 'norms' in Healthy Men above 40 years age ; same authors- Ind. Jour. Med. Res, 55,599.

24.1.7 Conclusion.

The art of diagnosis is always a matter of weighing probabilities and possibilities and looking at the total evidence. This demands expert judgement based on the interpretation of the above criteria. Incorrect diagnosis may result in unfounded socio-economic and psychological damages. Moreover, it may result in treatable diseases remaining unattended.

25. Lung Cancer.

25.1 Lung cancer attributable to asbestos does not generally occur untill several years after the initial exposure, similar to other environmental carcinogens.

25.2 Epidemiological studies have shown that the risk of lung cancer is greater at higher levels of asbestos exposure. Even so, the non-smoking asbestos workers are at less risk of contracting lung cancer than cigarette smokers in the general population.

25.3 Certain Western epidemiological studies on workers who are occupationally exposed to low levels of asbestos dust concentrations have not shown lowering of life expectancy or excess mortality from lung cancer.** This suggests that regulated and controlled usage of asbestos may reduce the level of risk to even to those of the general population of same socio-economic level.

25.4 There are no specific features by which an individual case of lung cancer can be attributed solely to asbestos exposure.

25.5 — A peripheral cancerous lesion of the lung, particularly in the lower zone in an asbestos exposed worker is likely to be an asbestos induced lesion, more so in the presence of Asbestosis.

— Examination of sputum for the presence of cancerous cells is able to reveal existence of cancer, even in the absence of symptoms and signs, in a proportion of cases.

25.6 Latent period for lung cancer in an asbestos exposed worker is above 15-20 years.

25.7 It is recommended that lung cancer in asbestos workers be accepted as a disease caused by occupational exposure to asbestos, provided that—

25.7.1 there is a clear and adequate history of atleast 10 years continuous occupational exposure to asbestos or there is an adequate history of asbestos exposure of atleast 10 years back and

25.7.2 it is found in the presence of asbestosis or bilateral pleural thickening.

26. Mesothelioma.

26.1 Diffuse malignant mesothelioma of pleura or peritoneum is a rapidly progressive fatal disease. In the general population it is rare but its prevalence in asbestos exposed workers is recorded to be more frequent.

26.2 Latent period for mesothelioma is generally over 30 years from first occupational exposure to asbestos.

** "Further follow-up study of workers from an asbestos cement factory" by H.F. Thomas Et al ; British Jour. of Ind. Med. 1982 ; 39 : 273-276.

"Mortality of workers manufacturing friction materials using asbestos" by G. Berry & M.L. Newhouse—British Jour. of Ind. Med. 1983 ; 40 : 1-7.

"Influence of doze and fibre type on respiratory malignancy—risk in asbestos cement manufacturing" by Hans Weill Et al; American Rev. of Resp. Disease; 120 (2) : 345-354. Aug. 1979.

26.3 Smoking habit plays no role in the genesis of mesothelioma.

26.4 Epidemiological studies have recorded virtually no peritonial mesothelioma and non significant prevalence of pleural mesothelioma in chrysotile exposed workers.**

26.5 Radiological features of pleural mesothelioma may vary from massive effusion to gross pleural thickening.

26.6 Diagnosis can be made at biopsy or at autopsy. But again, mesothelioma has varied histological features and requires great deal of expertise to identify it.

26.7 Fibrous zeolites (Eriorite) have been definitely associated with the causation of malignant mesothelioma in human beings@@. There is a list of possible and probable agents known to cause Mesothelioma in experimental animals-these are :

26.7.1 **Possible :**

- Glass fibres
- Aluminium Oxide
- Attapulgite
- Silicon carbide
- Potassium titanate
- Wollastonite

26.7.2 **Probable :**

- Pleural tuberculosis
- Beryllium
- Radiation

26.8 When Mesothelioma is found in an asbestos worker the disease is deemed to have been caused by asbestos exposure for the purposes of compensation provided the following condition is met :

26.8.1 There is a clear and adequate history of atleast 15 years continuous occupational exposure to asbestos

or

26.8.2 There is a minimum interval of 15 years between first exposure to asbestos and appearance of Mesothelioma.

Medical Surveillance

27. General

27.1 All persons potentially exposed to asbestos fibres above the Action Level*** should be kept under medical surveillance. The Study Team recommends that, presently in India, we may set 0.50 f/ml as the Action Level.

** "Asbestos-the control limit for asbestos" by E D Acheson & M J Gardner published by Health & Safety Commission, UK, 1983 (Para 107—Page 16)

@@ "Environmental mesothelioma in Turkey" by BARIS YI et al Ann. Ny. Acad Sci; 1979; 330 : 423-432.

*** The ILO Code of Practice "Occupational Exposure to Airborne Substances Harmful to Health", 1980, defines Action Level, as under :

"A level of exposure of workers to airborne harmful substances in the working environment to be determined by the competent authority. It is distinctly below the exposure limits and consequently exposures below the action level do not usually necessitate application of all the preventive measures, for example those of a medical nature often required for exposures exceeding the action level. The action level will generally lie at or below half of the exposure limit".

27.2 Medical surveillance should be provided at no expense to the employee, and medical evaluation should, so far as is practicable, be conducted during working hours.

27.3 Medical surveillance programme should consist of :

(a) Pre-employment medical examination.
(b) Periodic medical examination.
(c) Medical examination at cessation of employment.
(d) Medical Records.
(e) Health education.

28. **Pre-employment Medical Examination.**

A medical examination of the worker should take place upon recruitment or prior to assignment to a place of work involving exposure to asbestos dust.

28.1 **Objectives.**

28.1.1 To determine any condition which would be a contra-indication to occupational exposure to asbestos; examples are: the worker with markedly reduced lung function than predicted values (FVC and FEV_1%)** and the worker with a gross radiological lung abnormality should be prevented from joining work entailing potential exposure to asbestos. The worker with chronic bronchitis, asthma, bronchiectasis, gross cardiac impairment, gross chest wall abnormality, active or inactive tuberculosis should not be employed in a place where there is a potential exposure to asbestos dust. Persons below 18 years of age should not be employed for such workplaces.

28.1.2 To educate and advice workers about the health hazards due to occupational exposure to asbestos, the preventive/protective measures provided by the employer and the precautions to be taken by the employee.

28.1.3 To establish baseline medical records for further surveillance.

28.2 **Structure of Pre-employment Medical Examination**

The pre-assignment medical examination of workers whose work is likely to involve them in exposure to asbsetos dust should include :

28.2.1 a case history which includes the occupational history of the worker with an emphasis on the respiratory system, previous occupational exposure to fibrogenic industrial dust, especially asbestos and smoking history;

28.2.2 job details that could allow reconstruction of the past exposure profiles for study;

28.2.3 a general physical examination, with an emphasis on the cardio-respiratory system;

18.2.4 a full sized postero-anterior chest radiograph to be obtained and interpreted using the most recent ILO guide-lines and

28.2.5 spirometry, in order to obtain representative forced vital capacity (FVC) measurements and forced expiratory volume in one second (FEV_1).

NOTE : In addition, lung function tests (spirometry) should be done every year for first two consecutive years to establish a more reliable baseline data. In case any gross difference is observed in these tests, a repeat test should be done after six months of second test.

29. **Periodic Medical Examination.**

29.1 **Objectives.**

29.1.1 To detect the earliest signs and symptoms of asbestos related diseases.

29.1.2 To detect the earliest signs and symptoms of a non-occupational illness which could present a similar picture of interstitial fibrosis, and advise the employee accordingly.

29.1.3 To record any significant change in health status relative to baseline observations.

** Table 1—Normal Standards of Pulmonary Function Tests for Healthy Indian Men 15-40 years old : Comparison of different Regression Equations (Prediction Formulae) by S. K. Jain & I.J. Ramiah : Ind. Jour. Med. Res. 57, 8 August 1969.

29.1.4 To continue to educate & advise management and employees about health risks, and to ascertain that appropriate preventive measures are being taken to minimize risk.

29.2 Structure of Periodic Medical Examinations.

Periodic medical examination of persons potentially exposed to asbestos dust should include :

29.2.1 a relevent, brief medical and occupational history including smoking habits;

29.2.2 job details that could allow reconstruction of exposure profiles;

29.2.3 a clinical examination, with an emphasis on the respiratory evaluation;

29.2.4 a full sized postero-anterior chest radiograph to be obtained and interpreted using the most recent ILO guidelines. The findings are to be compared with those of previous chest radiographs;

29.2.5 spirometry to obtain a representative FVC and FEV_1 for comparison with previous measured values;

29.2.6 additional tests as necessary for diagnostic purposes, particularly in workers with signs and symptoms suggestive of asbestos-related diseases.

29.3 Frequency of Periodic Medical Examinations.

29.3.1 Every worker, irrespective of his exposure profile, should have his first periodic medical examination done, five years' after pre-employment medical examination. Thereafter, workers who are occupationally exposed to asbestos dust level which is more than Action Level (0.5 f/ml) should have periodic medical examination done every three years,

29.3.2 The ILO Code of Practice, "Occupational Exposure to Airborne Substances Harmful to Health", 1980 mentions that exposures to dust levels below the Action Level do not necessitate application of preventive measures of a medical nature (Para 27.1 above refers). However, as a matter of extra precautionary measure, the Study Team suggests that this category of workers should get medical examination done, every ten years.

29.3.3 Periodic medical examinations may be conducted more frequently if the occupational physician deems it necessary, based on the findings of the previous medical examination. Needless to mention, a more frequent medical examination is justified only to confirm a suspected case of asbestos-related disease.

30. Interpretation.

30.1 Radiographic Evaluation.

30.1.1 Radiographic evaluation of the worker exposed to asbestos dust should be based on the "ILO 1980 International classification of radiographs of the pneumoconioses" or any subsequent revision thereof.

30.1.2 The occupational physician may ask for additional views of the chest, like, lateral or oblique, in selected cases, for further information.

30.2 Pulmonary Function Evaluation.

For recording FVC, FEV_1 a device which provides a tracing of volume-flow or volume-time curve during the entire forced expiration is recommended. The tracing should be stored & available for recall.

While recording FVC and FEV_1 the technique should be properly demonstrated and a minimum of three acceptable manoeuvres should be performed and the maximum value out of these should be recorded. Predicted values of lung function of that ethinic group for comparison is an approximation accepted in the absence of pre-employment and periodic medical examination observations in the older employees. Additional examination of respiratory function may be necessary for appropriate diagnosis, particularly in subjects with evidence of respiratory symptoms or functional impairment on spirometry.

31 Medical Examination at Cessation of Employment

31.1 Upon the cessation of employment, a full medical evaluation including review of all investigations done during periodic medical examinations should be performed.

31.2 The employer should arrange for the medical examination of the employee within 30 days of termination of employment.

31.3 At this medical examination, if the worker is suspected to have any abnormalities related to asbestos, he may be called for further periodical medical examinations. A copy of the pertinent findings of this medical examination should be provided to the worker at this time.

32. Medical Records

32.1 Medical records should be maintained in accordance with good medical practice, recognising the long latent period for asbestos related diseases.

32.2 Medical records should be maintained/stored for a period of 10 years following the termination of employment, or for 40 years after first day of employment, whichever is later.

32.3 Medical records should include the details of pre-employment examination, the periodic medical examinations, and the medical examinations conducted at other time, if any.

32.4 As part of overall medical record, records should also be maintained of the individual employee's occupational exposure profile to asbestos, specific work practices and preventive measures prescribed, if any.

33 Health Education/Appraisal of Health Hazards

33.1 Every employer should ensure that all workers(employees) on employment and at periodic intervals should get education and training in regard to sources of asbestos dust exposure, potential health effects, risk associated with asbestos dust exposure and smoking and, methods of prevention.

33.2 The employer must apprise the employees of adverse synergistic effect of smoking cigarettes, beedies, cigars and occupational exposure to asbestos. It is suggested that this information be made available to all workers exposed to any level of airborne asbestos particulates.

34 Medical Panels

One of the points amongst the terms of reference assigned to this Study Team was to recommend on the formation of medical panels and their composition, for providing final diagnosis in cases of dispute or doubt. The Study Team considered that :

34.1 in view of the complexity surrounding the diagnosis of Asbestosis and other asbestosrelated diseases, separate medical panels should be created for adjudicating on all cases of such diseases and entitlements for compensation;

34.2 panels should be created in different regions, keeping in view the geographical density of asbestos based industries. This will be conducive to early disposal of disputed cases;

34.3 such panels could be created under suitable enabling provisions of the Factories or the Workmens' Compensation Acts and should function in addition to the Pneumoconiosis Boards/Panels under the Indian Mines & the ESI Acts;

34.4 such panels should also function as referal bodies in cases of asbestos related diseases for workers not covered by the Indian Mines Act or the ESI Act;

34.5 preferably, such panels should comprise of the senior-most chest physician or a senior professor of chest diseases of a teaching hospital, the professor of diagnostic radiology or a physician who has been especially trained in industrial dust diseases preferably those related to asbestos dust or an experienced occupational health physician, if available. Otherwise, a panel would have two chest physicians and one radiologist as members, with the senior chest physician as the presiding officer;

34.6 in view of dearth of medical expertise in diagnosing Asbestosis and asbestos-related diseases, it is desirable that the members of the constituted panels are encouraged to visit the recognised institutions and panels abroad to obtain specialized training and experience in this field;

34.7 such panels may refer to each other in cases of doubt but their decisions would be final and not justiciable or referable to panels of seemingly increasing importance;

34.8 opinions of national or foreign experts, if obtained in a particular case or cases, should be made available to the appropriate panel for its consideration.

FINAL REPORT OF THE STUDY TEAM 'B' FORMED UNDER THE AEGIS OF THE COMMITTEE "TO STUDY THE HEALTH HAZARDS IN ASBESTOS INDUSTRY" CONSTITUTED BY THE DGTD PANEL ON ASBESTOS PRODUCTS INDUSTRY

PREFACE

In pursuance of the decision taken by the DGTD Panel on Asbestos Products Industry to constitute a Committee to "study the health hazards in asbestos industry", a study team designated as Study Team 'B' under the aegis of this Committee was constituted. The study Team 'B' was assigned the task of examining the adequacy or otherwise of the existing legislative provisions for protecting occupationally exposed workers from the risk of asbestos induced maladies.

The Chairmanship of the Study Team 'B' was entrusted to me by the Committee and I had the privilege of heading the team of 10 eminent expert members who were specially drawn from the Government regulatory agencies responsible for the Factories, Mines Safety, Environment, the Industry and the Asbestos Information Centre in order to provide a broad spectrum of experience concerning the subject. The expertise of the members has indeed been of immense value in the study and critical analysis of this complex subject.

I wish to place on record the ready and whole-hearted co-operation that the Team received at all places it visited, including asbestos mines and the factories. The visits afforded the opportunity for a free exchange of ideas with the producers of asbestos fibre and asbestos-based products both in the large as well as the small scale sectors. I, on behalf of my Team members and myself would like to express my grateful thanks to the management of the mines and various industries and their personnel who helped us to compile the factual data and relevant information on the status of protective measures that had been adopted by them.

I would also like to gratefully acknowledge the active advice and guidance that I received from my team members who showed great commitment and dedication to the task and did not hesitate to readily give their valued time for the series of meetings and study visits to distant and far flung places like Cuddapah in the Andhra Pradesh, Udaipur region in Rajasthan, Hyderabad and Bombay.

I would finally like to thank Mr. D.K. Biswas for providing me this opportunity to lead this competent team of experts in their respective fields connected with the task assigned to me, as the Chairman.

Sd.
(Dr. G.G. DAVAY)
Chairman of Study Team 'B'

Hyderabad,
May 23, 1985

FINAL REPORT OF THE STUDY TEAM 'B' FORMED UNDER THE AEGIS OF THE COMMITTEE "TO STUDY THE HEALTH HAZARDS IN ASBESTOS INDUSTRY" CONSTITUTEDBY THE DGTD PANEL ON ASBESTOS PRODUCTS INDUSTRY

Terms of Reference

1. The terms of reference assigned to the Study Team 'B' was to examine the adequacy or otherwise of the existing legislative provisions for protecting occupationally exposed workers from the risk of asbestos induced maladies. Later on, the Study Team 'B' was also assigned the task to study in depth all aspects of Workmen's Compensation Act, ESI Act and insurance cover for the asbestos workers.

2. Under the first term of reference, the Team was required to study the Factories Act, Model Rules and Schedule XIV on asbestos framed under the Factories Act, other guidelines issued by the Government of India, the Mines Act and the Draft National Regulations formulated by the Asbestos Information Centre (AIC).

3. Under the seeond term of reference, the Team was asked to include in its study the agency for deciding the claims of compensation, the level of compensation and the policy of the nationalised insurance companies regarding insurance cover for disablement arising from exposure to asbestos dust.

Study Team and its Action Plan

4. The Study Team 'B', comprised as under, was constituted by the Committee "To study Health Hazards in Asbestos Industry" during its First Meeting held on 25th February, 1984 in the Department of Environment, Bikaner House, New Delhi:

(a)	Dr. G.G. Davay	Chairman
(b)	Dr. V.P. Gupta	Member
(c)	Dr. G.K. Pandey	Member
(d)	Mr. G.S. Ichhpurani,	Member
(e)	Mr. B.K. Sharan	Member
(f)	Mr. N. Venkataraman	Member
(g)	Mr. J.B. Amin	Member
(h)	Mr. V. Pattabhi	Member
(i)	Brig. D.B. Kapoor,	Member
(j)	Dr. P.K. Sishodiya	Member

5. The first Meeting of the Study Team 'B' was held on 1st September, 1984 in the Factory Inspectorate Office at Bombay. During this meeting, it was decided that indepth knowledge of the working conditions in various types of asbestos based industries, asbestos mines and docks would be essential to enable the Team to make effective and practical recommendations. It was thus decided that the Study Team should visit various asbestos factories/mines and the docks. Consequently, visits were organised to the mines at Cuddapah and in the Udaipur region and asbestos milling plants at pitheads and asbestos product manufacturing units at Hyderabad, Bombay and Udaipur region. The existing provisions under the Factories Act, Schedule XIV on asbestos and Model Rule 123A were reviewed. Simultaneously, the provisions of the asbestos regulations of the Western Countries like Ocupational Safety and Health Administration (OSHA) Standards, U.S.A., Asbestos Regulations, U.K. and the Draft National Regulations, formulated by the AIC and the ILO Code of Practice were studied. The Study Team also took up for review the modified provisions of the Workmen's Compensation Act, ESI Act and the applicability of general insurance cover so far as it relates to asbestos-related occupational diseases. The knowledge and experience gained by the Team from these reviews/visits were fully utilised in making its observations and drawing up its recommendations.

6 The report on the visits of the Study Team to the asbestos mines and pithead milling plants is given at Appendices 'A' & 'A1.' Teams' report on its visits to the asbestos products manufacturing units is given at Appendix 'B'.

Observations

7. General

7.1 The visit to various asbestos factories, mines and pithead processing units revealed that the workers in these units are subjected to exposures which vary from levels much below the accepted levels at one extreme, to highly objectionable dust levels at the other. Under these conditions, it would be reasonable to assume that the anticipated health risks will be in relation to the variations in the exposure levels. The widely differing exposure levels observed at the various sites visited is attributable to two important reasons.

7.2 The first point of importance is the process employed or the type of plant and equipment used by the units. In most cases, where the dust levels were visually observed to be above the accepted levels, the process employed was part mechanised and part manual and the plant and equipment did not possess and/or provide even the simplest of dust control methods. There are certain processes inherently dust prone, such as, whipping up of asbestos containing ore or asbestos fibre in the open in dry state by means of mechanical equipment. There are other processes where there will be least release of dust even with minimum precautions. So, it is essential that each of the processes is studied to determine whether the operations can be performed with better process techniques or better equipment and whether appropriate dust control measures are likely to bring down the dust levels to acceptable levels. Knowledge of State-of art in the process will help to make proper decision. If such a possibility does not exist, the process should be abandoned or considered hazardous, requiring the use of approved personal protective equipment until desired modifications to the processing plant are implemented. In no case should personal protective equipment be considered a permanent substitute to effective preventive engineering control methods. It can at best be a contingency measure, to reduce personal exposures.

7.3 The second point of importance is the level of implementation of the in-house hygienic standards. There are units where the Team noticed adherence to these standards at one end and a total neglect of the same at the other end. One reason for the latter is the ignorance and lack of knowledge about the hazards and implications in the handling and use of asbestos.

8. Legislative Regulations for Asbestos

8.1 Factories Act & Rules

8.1.1 The existing definition of the word "asbestos" in the revised Schedule XIV was examined and the Committee found it adequate, as mentioned below :

"Asbestos" means any fibrous silicate mineral and any admixture containing actinolite, amosite, anthophylite, chrysotile, crocidolite, tremolite or any mixture thereof, whether crude, crushed or opened."

8.1.2 The provisions under "Application of Rules" and "Method of Monitoring" given in Schedule XIV are considered adequate. However, some minor changes are required.

8.1.3 The committee examined the existing Model Rule 123A for the permissible exposure limit values for asbestos. The Committee felt that there should be no distinction for different types of asbestos fibre and that the standard permissible exposure limit value of 2 fibre/cc is considered adequate. This provision has now been included in the Revised Model Rule 123A.

8.1.4 Schedule XIV on asbestos and the Model Rule 123A specifying the permissible limit of exposure have not yet been adopted by many of the States.

8.1.5 The method of sampling and estimation of the asbestos fibre dust in workplace environment is not provided in the Schedule. Also, ere is no national standard method for workplace environmental sampling and asbestos d:. level measurements.

8.1.6 An exposure level of TWA recommended in the Model Rules should be further explained to include sampling strategy. ISI should be requested to incorporate these details in the Standards for measurement of airborne fibrous dusts.

8.1.7 The Team considers that the measurement of asbestos dust levels is a complex technique liable to wide variations unless enough expertise is developed with the assistance of well established asbestos dust counting laboratories.

8.1.8 There should be a procedure and programme to standardise the practical aspects of counting of the fibrous dust to reduce inter-laboratory variations.

8.1.9 The Team is of the view that no sampling and analytic technique other than the Membrane Filter Technique (MFT) be used as no accepted formula exists to corelate countings by different methods and MFT is by far the most practical and economical method universally accepted for this purpose.

8.1.10 The revised Schedule XIV now specifies 2f/cc as the TWA for all types of asbestos dust. The study Team is aware of the trend in the advanced countries to further lower the permissible limit. However, after careful consideration of the present techno-economic feasibility in India to implement the standard and bearing in mind that several countries, e.g. Japan, still consider 2f/cc as adequate, the Study Team feels that the present recommeded permissible level of 2f/cc is the practical provision at this point of time.

8.1.11 It is also considered that Short Time Ceiling Value of 10f/cc on a 10 minute sampling period may be accepted.

8.1.12 Method of sampling suggested by this Study Team is included as Appendix'C.' It is, however, suggested that the ISI should soon bring out a standard for the measurement of fibrous dusts which should then be uniformly adopted.

8.2 **Small Scale Industry**

8.2.1 During the visits to small scale units already in operation it was observed that they neithe have the adequate financial resources nor the technical competence to come to grips wit the problem and to take suitable control measures.

8.2.2 As these units are already established and are in operation, the Team recommends th these units be assisted to implement the regulations much the same way an SSI unit helped to establish manufacture, by way of several incentives both financial and technica We are afraid that the alternative will be prohibition of the use of asbestos and other suc toxic substances by the Small Scale Industry. The areas where these units require assi tance are as follows :

— *Financial* : Subsidy should be given for the purchase of equipment needed for t control of dust, personal sampling etc. Capital assets under this category should not counted for the capital investment clause which determines classification for Small Sc Sector.

— *Engineering* : A technical cell in D.I.C. or other concerned agency should directed to pool the technology for the suppression/control of asbestos dust and to h the Small Scale Industry to select and install appropriate equipment.

— *Measurements & Health Control* : The Small Scale Industry should be encouraged to p their resources and establish a centralised dust counting centre, as also a health surve ance centre under the supervision of a competent qualified person.

— *Education* : Employees in this industry should be made aware of the need for strict plementation of the asbestos regulations and the health hazards that might arise due occupational exposure to asbestos.

8.3 Mines Act; Regulations & Rules Thereunder.

8.3.1 During visit to the underground mines, fibrous deposits were noticed on the roof, walls and floor which were dry and were not kept wet in the travelling and haulage roadways.

8.3.2 Relevant regulations of MMR 1961 do not provide for environmental survey of open cast mines and underground mines less than 50 metre depth. These also do not contain appropriate methodology for counting the asbestos fibres present in the uuderground working environment. It is necessary to provide for such surveys and suitably amend the MMR 1961.

8.3.3 The open cast mines in Udaipur were mining the ore deposits manually without wetting. It is necessary to monitor these workplaces, to approve the present method of working.

8.3.4 During the visit to the mines, the Team also observed the milling process being carried out in the nationalized as well as in the joint and the private sectors.

8.3.5 It was observed that the processing is carried out using small machines without total/partial dust control measures, resulting in unsatisfactory dust level exposures to the workers.

8.3.6 The scale of operation of these mines will not allow the installation of the required plant for achieving acceptable dust exposure levels as the cost of such plants are reported to be approximately one crore of rupees.

8.3.7 The Team suggests that the milling operation be pooled to enable installation of modern milling plant with complete dust control systems & provision for safe disposal of asbestos waste & tailings.

9. Compliance of Regulations.

9.1 It is observed that State regulatory agencies entrusted with the task of implementing the controls on asbestos and other toxic substances are presently not adequately equipped with proper equipment and other resources, including trained man-power. These facilities are essential to ensure adequate compliance to protect the health and safety of the workers.

9.2 The industry should periodically monitor dust levels to ensure the effectiveness of the engineering controls.

9.3 The Team received the record of monitoring from several industries. Whichever of the industry units that has not yet implemented the monitoring scheme is advised to do so without any further loss of time.

9.4 The Team requests the Government to be liberal in allowing importation of the latest equipment required for the purpose of monitoring dust levels and medical surveillance of emploees

9.5 Some of the small scale manufacturing units and pithead processing units had emyloyed children and adolescents who were being exposed to heavy dust exposures. The Team considers that this practice be prohibited.

10 Licencing of New Manufacturing Units.

10.1 During the visit to various factories the Team observed that several equipment and plant now being used are not by design meant to process asbestos fibres/products but have been adopted for the purpose in an adhoc manner by the management. It is felt that equipment and plant used for this purpose are manufactured scientifically, taking into consideration the need to keep the air-borne asbestos dust within the permitted exposure levels, whether it is within the factory or in the stacks, when let out into atmosphere. While the Government now requires specific environmental pollution control measures before any new licence is granted such specific provision to control workplace exposures is not existing. Notwithstanding the provisions existing in the Factories Act and Rules, it is recommended that the appropriate authority should satisfy itself that adequate provisions are made before licensing further units. The provisions should be specific and not general in nature to avoid subjective decision making and to ensure uniformity.

10.2 The Team has also been informed of certain manual operations where no power is used and hence, may not come under the purview of any regulatory agency. It is the considered opinion of this Team that all such operations and places be brought under Central/State regulatory agency by the use of enabling provisions under the main Act.

11. Packaging & Handling of Asbestos Fibre.

11.1 The Team has taken note that certain openations are carried out outside the factory where asbestos is handled at places where the factory rules are not applicable, prominent among them being the handling of raw asbestos, both-imported and indigenous.

11.2 The Team observed that fibre produced indigenously sometimes is packed in ordinary jute bags. Such a practice should be prohibited. All asbestos fibre should be packed securely in impermeable bags. Such a bag can be had with an inside polyethene film lining. Woven plastic bag with inside lining is preferred. Use of hooks should be strictly avoided and such an instruction should be printed on the bag.

11.3 When imported, the asbestos fibre should be unitised. Handling of individual bags should be avoided as far as it is practicable. Handling procedures at the docks should be standardised to encourage the use of mechanical handling equipment to unload and carry the unit loads.

11.4 ISI should be requested to formulate a Code of Practice for the guidance of the asbestos users, both in factory and non-factory operations.

12. Medical Surveillance.

The methodology to adopt medical surveillance is a subject for another study team whose findings would need to be integrated with this Report.

13. General Environment.

13.1 The Team has not studied the emission of asbestos dust from the asbestos product manufacturing factories or asbestos processing units into the general environment. This aspect was beyond the purview of its terms of reference. However, the Team considers that the State Pollution Control Boards should look into the feasibility of bringing out standards for emission of asbestos dust into the ambient air.

13.2 The Team observed that the solid waste tailings from the raw asbestos processing units was being stored in the open and then, disposed off to the public, which is hazardous. The Team considers that a Code of Practice for the disposal of solid waste tailings be drawn by the Department of Environment/Pollution Control Board/ISI in accordance with international practices.

14. Compensation.

14.1 At present, the Workmens' Compensation Act, 1923, covers asbestosis; lung cancer and mesothelioma when they are caused by asbestos. However, there still exist some uncertainties in the interpretation of these provisions.

14 2 Criteria for the diagnosis of the above mentioned asbestos-related diseases need to be specified.

14.3 In case of lung cancer and mesothelioma, it is known that several other factors could cause the same diseases and hence, there should be criteria for identifying them as related to asbestos exposure; for example, in the U.K. when lung cancer is present alongwith asbestosis or bilateral pleural thickening asbestos is deemed to be its cause for the purpose of the compensation.

14.4 There is also a need to designate an agency with specialized training to decide the eligibility of claims for compensation from the medical angle.

14.5 The ESI Act does not make provision for compensation after the employee—ESIC relationship has ceased to exist. The ESI Act should be ammended such that the ESIC is made liable to pay compensation, even after cessation of employee—ESIC relationship, for diseases covered under Schedule III, Part C of the Workmen's Compensation Act. In addition, ESIC should be required to provide life long medical facilities in such cases.

14.6 Employees not covered under either of the above Acts are not eligible for any compensation. The employers should be asked to take insurance with National Insurance Companies for all their employees not covered by the ESI Act. Such Schemes should cover the life of the employee and not the period of his employment.

15. Substitution.

The Study Team noted that DGTD Panel on Asbestos Products Industry is already seized with the aspect of substitution of asbestos fibre by alternative fibrous materials based on technical considerations provided they are less hazardous to health and offer equivalent techno-economic advantages. In views of this, the matter was not pursued.

16. Recommendations.

As a results of the visits, deliberations and the observations made in the preceding paragraphs, the Study Team offers the following recommendations :

16.1 Current prescribed level of 2f/cc as specified in Model Rule 123A is considered adequate at the present time. MFT should be used for the measurement of the air-borne asbestos fibre dust (ISO draft is available).

16.2 Framing of Rules according to the Schedule XIV and Model Rule 123A by the concerned States is an urgent requirement.

16.3 — Effective steps to implement the above Rules must be taken by providing all facilities to the state regulatory agencies. These include dust monitoring equipment and specilised trained man-power in order to produce accurate and re-producible results.

— Measurement of fibre dust levels is a complex subject and efforts should be made to obtain uniformity within industry and regulatory agencies.

16.4 Personal protective equipment should not be considered a permanent solution in place of preventive engineering control measures. At best, this should be a contingency measure.

16.5 Every process and equipment related to the milling of asbestos ore and processing of asbestos fibre should be studied for its potential to create air-borne dust. In case any process/equipment releases dust that cannot be controlled to the desired limits by engineering control methods, such process/equipment should be prohibited.

16.6 Equipment used in the processing of asbestos should carry a certificate from the manufacturer that during normal usage as recommended, the equipment will not release fibre dust levels higher than the prescribed limit.

16.7 Management and control of asbestos dust in the small scale sector of the industry need to be tackled on priority basis. Major recommendations in this regard are:

— *Financial* : Subsidy should be given for the purchase of equipment needed for the control of dust, personal sampling etc. Capital assets under this category should not be counted for the capital investment clause which determines classification for small scale sector.

— *Engineering* : A technical cell in D.I.C or other concerned agency should be directed to pool the technology for the suppression/control of asbestos dust and to help the small scale industry to select and instal appropriate equipment.

— *Measurements and Health Control* : The small scale industry should be encouraged to pool their resources and establish a centralised dust counting centre, as also a health surveillance centre under the supervision of a competent qualified person.

— *Education* : Employees in this industry should be made aware of the asbestos regulations and the health hazards that might arise due to occupational exposure to asbestos.

16.8 — For licensing/registration of new units, specific requirements of dust control to be met by them should be listed out by the competent authority. Licence should be issued by the competent authority only after satisfying itself that such requirements have already been included in the project.

— All operations and places where asbestos fibre is used should be brought under the purview of the Factories Act and Rules, irrespective of the size of the workforce or usage of electric power.

16.9 — The regulation and rules made under the Mines Act 1952 need to be modified to bring them upto the International Standards for the control of asbestos fibre dust during mining, handling and milling of the ore.

— Where applicable, the rules under the Mines Act should be modified so as to include the relevant provisions of Schedule XIV and Model Rule 123 A made under the Factories Act so far as they relate to asbestos fibre dust control.

— Asbestosis ; lung cancer and mesothelioma when they are caused by asbestos should be notified as occupational diseases under the Mines Act.

— Specialised trained manpower and equipment are to be provided to effectively monitor the environmental exposures in mines and medical surveillance system of the mine workers.

16.10 State Pollution Control Boards should make emission standards for the control of asbestos fibre dust in the general environment.

16.11 Packing of raw asbestos fibre should be in impermeable bags and should be handled as unitised loads as far as it is practicable. Empty bags should be disposed off as per international practice and should not be given to the public. ISI may be requested to bring out the Code of Practice for packing, handling, transportation and use of asbestos fibre.

16.12 — The employees covered under the ESI Act should be eligible for compensation after cessation of ESI coverage, as is the case in Workmen's Compensation Act.

— Clear criteria for the diagnosis of asbestos related diseases should be specified and should be uniformly followed.

— In the case of lung cancer which could also be caused by various other reasons it should be made compensable only when either asbestosis or bilateral pleural thickening is concurrently present.

— There is need to designate an agency that possesses specialised training, expertise, competence and facilities to decide the cases entitled to compensation arising out of asbestos-related diseases.

— Employers should be required to cover their employees under general insurance in case they are not covered under the ESI Act.

16.13 Government should be liberal in allowing the import of equipment required for the use in dust monitoring and medical surveillance.

16.14 ISI may be requested to expedite formulation of :

— Standard for the measurement of airborne fibrous dust.

— Code of Practice for the packing, handling, transportation, and use of asbestos in the factory, mine and other places.

— Code of practice for the use of asbestos containing products.

— Code of practice for diposal of asbestos waste materials, including tailings and empty bags.

16.15 Following amendments to Schedule XIV on asbestos be carried out :

— The words "following operations shall be enclosed and provided with", be added before the words, "exhaust draught fitted with mechanical means" in sub-para (1) under para 4.

— The Clause 'd' under sub-para (1) of Para 4, be deleted.

APPENDIX-'A'

VISIT TO ASBESTOS MINES IN CUDDAPAH DISTRICT OF ANDHRA PRADESH

1. The names of the team members who visited the following mines and processing plants to study the health hazards in asbestos mines are given in Annexure I :

   (a) Joint Sector Mine.

   (b) State-undertaking Mine.

   (c) Small Private Mine.

2. The Team reached Pulivendla at about 10.00 A.M. on 15th January 1985. The general mining method and operations were explained to the Team by Mr. G.S. Ichhpurani, Deputy Director-General of Mines Safety, Southern Zone. Mr. P. Choudhary, Managing Director, A.P.M.C. and Mr. K.V.S. Ram, General Manager, A.A.C. Ltd. explained the general geology and method of working of their mines.

3. General mining operations involve drilling, blasting, sorting, loading of the ore into the tubs and hauling to the surface. The run of mine ore is processed at surface mill, details of which are given subsequently. Only Chrysotile asbestos fibre is mined at Pulivendla.

4. There are about 10 underground asbestos mines situated in Pulivendla area. The total strike length of the deposit is about 14 Kms from Brahmanapalli to Velidandla village. The ore body outcrops. Asbestos occurs due to metamorphism of dolomite rock. Asbestos occurs as very thin deposit in serpentine vein. The thickness of the asbestos veins vary from few m.m. to 250 m.m. The average thickness is about 10 to 30 m.m. The thickness of the serpentine vein is about 1 metre. The general rate of dip is 1:4.5. The asbestos bearing rock was proved upto a depth of about 200m. The present depth of the deepest working mine is about 125 metres. General geology of the mine is same for all the mines. The biggest mine belongs to the A.P.M.C. which is a State undertaking. Four mines are worked by Andhra Asbestos Corporation Ltd., which is joint sector (A.P.M.C. and a Public Sector). Other mines belong to private mine owners.

5. *Method of Working.* The method of working is almost the same in all the mines. Inclines are driven from the outcrop and serpentine vein is developed in a bord and pillar pattern. Height of the drives varies from 1.5 metres to 2 metres and the width of the galleries varies from 2.5 to 3.0 metres. The size of the pillars varies from 5.5 m x 6.5 m to 15 m x 15 m (solid). The mineral blocks are stopped out by overhand/or breast stopping by cut and fill, method. The drives are blasted in two rounds. The lower half, containing the mineral, is blasted in second round. The mineral obtained from the underground is brought to the surface by direct haulages.

Joint Sector Mine—Date of visit 15.01.85.

6. The General Manager explained the method of working. The additional information required by the members was furnished by Mr. G.S. Ichhpurani. After studying the plans, the team went down through the manway to 1st level and travelled upto 2nd dip and went down to 4th level through 2nd dip, and entered the return airway through the air crossing and reached the 8th level through companion dip. After studying the general layout and the method of working, the team went upto 4th level and inspected the old stopped out area (Panel No. 1) which had been worked by the previous owners. The team returned to the surface through the same route. During the visit, it was observed that harmful dust was deposited on the sides of the travelling roadway.

7. The working environment, ventilation system and general surroundings in actual working and operations were observed by the Team members.

8. *Processing of Mineral.* Then, the Team members visited the processing plant. The run of mine is loaded manually into the tub and hauled out to the surface. The run of mine is subjected to manual sorting of the asbestos bearing rocks (ABR). The ABR is then hand-combed for chipping off the asbestos bearing portion in smaller pieces ranging on an average 2.5 Cm. (1") pieces. This is collected and is known as asbestos concentrate. From the ABR, the serpentine rocks are removed as waste. The asbestos concentrate is fed manually into the hopper of the hammer mill. In the hammer mill, the asbestos and other minerals are separated which are fed to the double deck screen which has sieves of 10 and 40 mesh. The screening gives three fractions :

(a) Oversize.

(b) Middling.

(c) Tailing.

Tailing is the waste which generally does not contain appreciable quantity of asbestos. The oversize is recycled in the hammer mill and the middling fibre is sucked up by a cyclone and collected. Whatever solid comes from the separation of fibre in the hammer mill is again fed into the hauler. The fibre in middling is again subjected to double deck screening having mesh size of 16 to 40. Particles which are less than this mesh size are a waste, which is taken out for dumping. The fibre from the screen is again sucked up by the cyclone separator and the fibre is collected.

All the operations which involve feeding of discharged material to the other processing machines are conducted manually. It was observed that the air from the cyclone collector is thrown out into the external atmosphere without passing the same through bag filteration system. The fibre from the cyclone is collected and removed to blending area where different batches are mixed together. Then, the same is packed in HDPE bag and weighed. The packing is done in 25 and 50 kg. bags. The bags are not labelled with the hazardous properties of asbestos and its source.

State Undertakings Mine—Date of Visit 16.01 85.

9. The Managing Director and the Manager were present during the visit. The Managing Director explained the method of working. Then the Team went underground. The various operations such as drilling, mucking, transportation, charging and blasting were arranged so that the Team could study the dust problem in various mining operations.

10. The Team went down by main travelling roadway to 2nd level and through the winze No. 23A went down to level No. 6 and then reached the level No. 7 through the air crossing. Then through No 4 incline and winze 12A, the Team reached level 9 and inspected the following faces :

— Level 9 East face-drilling operation.

— 11 dip of 9th level-mucking operation.

11. The charging and blasting were arranged in level No. 9. First round of blast for 12th dip was arranged. Six holes of 1.2 metres were already drilled and kept ready for charging. The holes were charged with two cartridges of slurry explosives with ordinary detonators and fuse. After observing the charging operation, the Team returned to the surface. Dust samples were collected from the airway.

12. The Team visited the processing plant. The run of mine is handled the same way as in the Joint Sector Mine. The asbestos concentrate is fed into the jaw crusher and sieved for grading. The jaw crusher crushes large size ABR. Smaller size jaw crushed ABR is fed to the disintegrator. The ABR obtained from the jaw crusher as well as the disintegrator are fed

to the edge runner. The lower wheel of the edge runner rotates and the vertical two wheels are stationary. The workers are required to push the material on the rotating wheel of the edge runner for obtaining effective pulverising. The pulverised material is manually pushed and collected in troughs and then collected in the baskets.

13. The pulverised asbestos containing mass is subjected to operation of decortication. In this process the fibres are blown out in a collecting room and the solids are separated. Then, the solids are subjected to another set of edge runners.

14. The collected fibre after decortication are sieved in eccentric sieves. The fibre so obtained is kept in separate batches and mixed together. In this fashion, the coarser solid particles are again pulverised in a huller which further separates the fibres and solids. The fibres obtained from different sources are mixed and packed.

Small Private Mine-Date of visit : 16-01-85

15. The Team went down through the manway upto the 7th level. Then, the Team came upto the 6th level through 2nd rise and inspected the following places :

— 11th dip of 6th level.

— 10th incline (main dip) drilling.

— 6th level-Blasting.

After inspecting all operations, the Team returned to the surface through the same route.

16. The Team, then, visited the processing plant. The run of mine is separated in the usual manner to obtain ABR. The ABR is pulverised in two stone wheel edge runners pulled by a tractor. The pulverised mass is subjected to decortication which separates the fibre from the solid rocks. The fibre is then subjected to sieving operations. The solids so removed are fed to the huller which further separates the fibre and the waste. The fibre obtained from different batches are mixed and packed in HDPE bags. Various operations undertaken in the processing plant expose the workers to the hazards due to asbestos dust.

17. The Team made the following observations :

(a) The workers undertaking the work of hand-combing and making asbestos concentrate are exposed to asbestos fibre. They are required to work in an open area under the sun throughout the year, including the summer.

(b) The first double deck screening operation, hammer mill, and hauler operations were emitting huge quantity of asbestos fibre in the work environment (visually).

(c) The collecting of the fibre from the outlet and out-going air from the cyclone system were also emitting asbestos fibre in the work environment.

(d) The operation of mixing different batches of asbestos fibre manually was also contaminating the work environment.

(e) ABR having longer asbestos concentrate were being manually hammered to sort out superior grade asbestos :

Grade 1 — More than $1\frac{1}{2}''$

Grade 2 — $3/4''$ to $1\frac{1}{2}''$

Grade 3 — $\frac{1}{4}''$ to $3/4''$

These were being subjected to manual jigging. The operation of jigging and hammering gave off asbestos fibre in the work environment.

(f) The overall observation of the Team was that the operation of hammermill, huller and cyclone operation were emitting huge quantity of dust exposing the workers and the population in the surrounding areas.

(g) Machinery and equipment as well as the auxiliary need to be redesigned so as to prevent emission of asbestos dust in the environment and the surroundings.

(h) Enclosures need to be provided to each of the operations with effective exhaust draught arrangements. The exhausted air from different sources should be passed through enclosed filter bags system and then, only the air which is not containing asbestos dust be let out into the external atmosphere.

(i) General house-keeping of the asbestos processing plants was very poor as asbestos was being handled without any regard to health hazards that it posed. Catridge type respirators provided to the workers were non-functional and unsuitable for effective use. Workers handling asbestos were completely unaware of health hazards of asbestos. There was no mechanical means to collect the dispersed asbestos fibre dust. Workers' clothes were seen to be highly contaminated with asbestos fibres. No suitable place was seen to be provided to store the personal protective equipment. No separate room was provided with dust de-contamination equipment. Workers were keeping their clothes near the workplace. Young persons were seen employed on all operations. No cautionary placards relating to injurious effects of asbestos were displayed in the asbestos handling plants. Only part-time medical officer was available for attending to the general complaints of the workers.

According to the management, workers employed in the mines are medically examined only once in five years. No system prevailed to monitor the work environment.

ANNEXURE-I TO APPENDIX 'A'

LIST OF STUDY TEAM 'B' WHO VISITED MINES IN PULIVENDLA, CUDDAPAH DISTRICT, ANDHRA PRADESH

1. Dr. GG. Davay,
2. Dr. V.P. Gupta,
3. Mr. G.S. Ichhpurani
4. Dr. G.K. Pandey,
5. Mr. J.B. Amin,
6. Mr. V. Pattabhi
7. Brig. D.B. Kapoor
8. Dr. P.K. Sishodidia
9. Mr. M.L. Dabral,
   Development Officer & Member Secretary,
   Panel on Asbestos Praducts Industry,
   Directorate-General of Technical
   Development
   Udyog Bhavan,
   New Delhi-110 011

APPENDIX 'A-1'

VISITS TO ASBESTOS MINES AND ASBESTOS PROCESSING UNITS IN RAJASTHAN

1. The Team Members had their first meeting at Udaipur on 21st February 1985, in the Office of Mr. N. Mishra, Director of Mines Safety, Government of India, Udaipur. The following members and invitees were present :

(a) Dr. G.G. Davay	Chairman
(b) Mr. G.S. Ichhpurani	Member
(c) Dr. G.K. Pandey	Member
(d) Mr. J.B. Amin	Member
(e) Brig. D.B. Kapoor	Member
(f) Dr. P.K. Sishodiya	Member
(g) Mr. N. Mishra	Invitee
(h) Mr. R.C. Chaudhry Dy. Director of Mines Safety	Invitee
(i) Mr. R.S. Sharma Suptd., Geologist Dept. of Mines & Geology	Invittee

2. Mr. N. Mishra and Mr. R.S. Sharma, informed that there were 45 working mines and 24 closed mines in Udaipur District of Rajasthan. One mine was having underground workings and the others were opencast. The production of asbestos during the year 1983 was 12,350 M.T.

3. The Deputy Director-General of Mines Safety explained that as per the records of Directorate-General of Mines Safety, there were 26 asbestos mines in Ajmer District, of which 18 were working mines. All these mines are opencast mines. The mines employ about 250 persons and produce 16,000 MT. of asbestos per annum.

4. It was decided to visit a few opencast mines in Udaipur District on 21.2.1985 and some asbestos products or processing units in Udaipur and Ajmer Districts on 22.2.1985.

Visit to Mines on 21.2.1985

5. **Kirat Asbestos Mine (Taluka Jhadol)**

The mine was being run on the sides of the hillock by opencast method. The size of the quarry was approximately 20 metres wide x 10 meters high. The sides consist of soft strata and were being worked by pick-axes. The management possesses a lease area of 299 hectares.

The production of asbestos ore is about 2,000 tonnes per month. The sides of the quarry were not kept properly benched. The run of the mine ore was being collected in"Tagoras" (M.S. Shallow vessels). The tagoras were carried on head and taken to a stacking place for breaking the ore. The ore was being graded into two grades, namely, No. 2 and No. 3. Grade No. 3 is very brittle and in in the powdery form. The graded run of the mine is carried in the trucks to the processing unit (s).

It was observed that even cutting the sides of the quarry by pick-axes raised small quantity of dust in the air. Similarly, the dust was raised while filling the tagora sand dumping at the place of grading as well as during loading of trucks. The workers were, thus, exposed to the asbestos dust. For grading the ore, at the mine, the run of the mines was screened manually. This also caused the dust to rise in the atmosphere at the working site. The average earning of a worker was stated to be Rs. 9.75 per day.

6. **Gangir Kiopal Asbestos Mine**

The mine was being worked by opencast method, on the sides of a hillock. The quarry was about 30 metres wide x about 20 metres deep. The sides were cut by axes as stated above. Proper benches were not formed. About 150 tonnes of asbestos ore is raised from the mine per month. The mine had started working in 1979. The operations in this mine were similar to Kirat Asbestos Mine as described above.

The asbestos ore was being sorted into two grades i.e. pipe grade and fibre grade for use in steel plants. The run of the mine ore is sent to a processing factory at Udaipur. Asbestos ore is also supplied as heat insulating material to various plants.

7. **Observations**

(a) In none of the mines medical examination of the workers was being carring out. The Director of Mines Safety informed that the medical examination of the workers in Udaipur District had not yet started. Deputy Director General of Mines Safety informed that the same information was received from the Director of Mines Safety, Ajmer, in respect of the mines in Ajmer District; in fact, no facilities exist for such an examination.

(b) No protection was provided for the workers against the hazards of asbestos dust in the mines and no control system had been introduced.

(c) The workers were not provided with any change over dresses for wearing during working and no arrangement was provided for the decontamination of their clothes from asbestos fibre dust.

Visit To Units Processing Mined Asbestos Ore And Asbestos Fibre On 22.2.1985

These units are located at Beawar and on the road to Beawar from Udaipur.

8. **Sindhari Minerals-Gomti Chauraya**

(a) The mined ore is subjected to following unit operations to separate the asbestos from ore:

— Jaw crushing.

— Pulverizing.

— Fine pulverizing.

— Cyclone for collection of product.

— Separation of the fibre (Cyclones and Bag Filters).

— Sieving of asbestos fibre.

— Bag filling operation—carried on manually.

(b) **Observations**

— Several of these operations to process asbestos ore into asbestos fibre are highly dust prone especially sieving, feeding to pulveriser and filling the bags.

— No dust collection system and exhaust draught arrangements exist. Thus, entire work atmosphere is contaminated with visval dust that includes asbestos fibre dust.

— Due to the above, dust is seen in all the places, eg. on the machinery, walls, floors etc.

— No dust measurement are carried out but it is obvious that dust counts will be high judging from the general dusty atmosphere.

— Personal protective equipment was not available.

— No provision exists to keep the worker's working clothes and street clothes separately

— No Medical examination scheme is existing/provided.

— Very young persons are employed in the plants.

— This unit is not reported to be covered under the Factories Act.

9. Diamond Asbestos Co. Deogarh, Chauraya.

The following unit operations are carried out to separate the asbestos fibres from the asbestos ore:

(a) Jaw crushing.

(b) Pulverising.

(c) Cyclone collection.

(d) Sieving the fibres.

(e) All filling and transportation operations are done manually using tagoras and powaras.

The observations on the working conditions in this unit are similar to those of the Sindhari Minerals, Gomti Chauraya, mentioned in 8 (a) above.

10. Asbestos-cement Sanitary Ware.

This factory also manufactures sanitary wares, bends, joints and other accessories.

Following operations are carried out :

(a) Mixing asbestos fibre and cement and then, water.

(b) Moulding of the product.

(c) Drying.

(d) Finishing.

(e) Curing.

Of these operations (a) and (d) are dust prone and, again, no precautions are existing. The factory employs 9 men and 5 women.

11. Oswal Mineral Trading Corporation, Deogarh. Kamli Ghat.

It employs about 7 men and 5 women. The factory processes about 10 tonnes of asbestos every day. Different grades of asbestos dust and fibre are pulverised. The pulverised material is collected and is carried and dumped or filled in the bags manually by tagoras and powaras. Different grades are prepared, which depend on the fibre content.

Observation.

No local ventilation or exhaust draught management is provided. The working conditions are more or less the same as in other factories, described earlier.

12. Sandra Mineral Trading Co., Beawar.

15 employees are engaged in manufacturing activities.

Mined asbestos is pulverised and stored in chambers. After chamber is full, the material is removed manually. The material is then graded and packed manually.

Observations.

(a) The entire area was contaminated with asbestos dust.

(b) The operations like pulverising, bagging, transportation etc. are more hazardous operations in this factory.

(c) There is no dust control and dust collection systems.

(d) The unit is registered under the Factories Act.

13. Rampal Asbestos Pipes, Beawar.

It employees seven persons and manufactures asbestos cement pipes and bends. Asbestos and cement are mixed in the mixer along with water. The mixture is poured over different mandrils for different diameters. The pipes are dried in the open. The dried pipes are finished by wheel cutters in dry state.

Observations.

(a) The employees are exposed to dust during mixing and at the finishing operations.

(b) No arrangements have been made to provide respirators at these places.

14. Lachuram Balaram Kunavat – Beawar.

The unit employees about 45 women and manufactures bends and othar sanitary fixtures.

Asbestos powder and cement are mixed in tagoras manually, along with water and the mix is used for making moulds for bends and other fixtures.

Observations are similar to other asbestos cement sanitary-ware units.

15. General Observations.

(a) Most of the processing operations are heavily dust prone. Mixing and finishing operations in A.C. sanitary-ware units are also dust prone.

(b) There is neither dust control system nor any dust suppression arrangements, resulting in visually high dust levels that certainly would include asbestos fibres. Both the general dust levels and asbestos fibre dust levels are bound to be higher than permissible limits A study of the measurements of dust levels is recommended.

(c) Recommended work practices, when dust levels are higher, require provision of personal protective equipment and their mainteinance and, the provision of change rooms. No such facilities exist in these units.

(d) Under the above conditions, settled dust is seen every where which can increase background dust counts.

(e) No medical check up is reported to have been carried out whether asbestos-related or of a general nature. The Team recommends the same.

(f) The Team observed that some young persons were employed who stand a higher risk of a dust related problems, including those from asbestos.

(g) General safety standards also leave much to be desired.

APPENDIX 'B'

VISITS TO ASBESTOS FACTORIES IN HYDERABAD AND BOMBAY

HYDERABAD

1 Asbestos Cement Products Factory : 17.1.85.

In addition to the Team Members, the Director of Factories and Boilers of Andhra Pradesh and his other officers visited this Factory.

The Team visited the Plant and observed various operations in the manufacturing process. The asbestos is fed to the Edge Runner Mill in entire bag form. The bag enters an automatic bag opening machine in which the fibres are dropped in the Edge Runner and the empty bag comes out separately. Water is sprinkled in the Edge Runner Mill to make the fibres wet to avoid generation of fibrous dust. The wet fibres are mixed and then used for blending. The Team also observed a new bag opening machine which has got an observation glass window. The fibres in the wet slurry form are mixed with cement which are further used for either making asbestos cement sheets or pipes. Handling of asbestos, from the starting stage to the wet mixing stage and after making cement slurry, is a closed system.

The wet cuttings of excess sheet are collected and sent back for recycling. The operation of finishing of pipe was also observed. The operation of cutting the cured pipes is done by circular cutter which has an effective local exhaust draught arrangement. Similarly, socket cutting and the turning machine is also provided with exhaust draught arrangement.

The factory has installed central enclosed filter bag system for handling the exhausted air from the different operational points. The factory has also installed a central static vacuum system for cleaning by suction the spilled asbestos from all the working places.

The reclamation of the broken sheets are done by cutting. This cutting operation is provided with water spray to suppress the dust.

Medical Surveillance Unit

The unit is equipped with X-ray unit, Micro Processor Controlled Recording Spirometer and a clincal laboratory with a full time doctor to implement the health surveillance programme. Records of the findings are kept seperately for every employee.

Environmental Control.

The Company has regular environmental control system. Audited and required records are maintained.

2 Small Scale Asbestos Cement Products Factory : 17.1.85.

The Team, then, visited a small scale factory engaged in manufacturing asbestos cement pipes. The asbestos package is charged into an enclosed Edge Runner Mill manually. Disinterated asbestos is collected at the outlet of the Edge Runner in bags. There is no provision for an exhaust fan arrangement at the inlet or the outlet of the disintegrator. Opened asbestos fibre is manually weighed and stored in gunny bags. Asbestos is then mixed in mixers with cement to form slurry for manfacturing pipes. The operation is of wet type. The pipes are cut to size by use of a circular saw. Dust is generated during this operation and the workers were not provided with any protective equipment.

3 Small Scale Non-Cement Asbestos Products Factory.

The Team then visited the factory engaged in the manufacture of clutch plates. Abestos fibre is kept in covered drums. Asbestos is then mixed with phenolic resins. The mixture is used for making clutch plates by use of power presses. The formed clutch plates are then subjected to grinding operations where there was no draught arrangement.

BOMBAY

4. Non-Cement Asbestos Products Factory : 26.3.85.

The Study Team visited this Factory in the forenoon of 26.3.85. This company manufactures brake linings/clutch facings (friction materials), CAF jointings, asbestos textile products, mill board etc.

(a) Friction Materials/CAF Jointings Plant.

The manufacturing processes observed in the case of Friction Materials and CAF Jointing were wet processes where once the asbestos fibres are fed into the mixer, along with other chemicals and the wet binders, the fibres get encapsulated with wet binder used—wet resins for friction materials and rubber solution for jointing materials. The mixings come out of the mixers in wet conditon and all further processing including forming and moulding of the linings/sheets are in wet form. The materials are then cured and are baked to get the final form, shape and size.

The mixing operations where asbestos fibres are fed were observed. In the case of the Brake Lining Plant, the pre-packed asbestos fibre bag is cut manually and charged into a bottom opening bin along with other raw materials, including the binder. This bin is raised and the raw materials are charged into the mixer body which is provided with sufficient negative pressure. In the case of CAF Plant, the asbestos fibres are fed into the hoppers of the mixers with negative suction at the feeding end itself, which ensures negligible dust emission. In both cases, the fibres dust level recorded in these operations (as per management records) is well within the 2 fibres/cc level

Linings and facings so produced, are then machined to dimensions in special purpose grinding machines/drilling machines where adequate dust collection systems are provided to remove swarf anddust produced in the machining operations. In the case of jointings, the sheets are cured in the calendering process and the subsequent finishing involves only cutting to size with scissor guillotine, where possibility of release of dust is negligible. The Team observed that all subsequent finishing operations were provided with eleborate dust collection systems wherever it is necessary.

The Team then visited the Asbestos Textile Plant of this Factory.

(b) Asbestos Textile Plant.

In the manufacture of Asbestos Textiles, different grade of fibre are received in pressure packed bags. These bags are cut manually and fed into blending hoppers with negative suction at the feeding end itself which does not allow any fibrous dust to come into the breathing zone of the operators. The blending operation is done in a totally closed system and the blended fibres are re-bagged in polythene bags manually under controlled suction conditions at the bagging stage

The blended fibres are then fed into the hoppers of the carding machines which are all maintained in total enclosure of flexible curtains made up of overlapping plastic strips. Adequate suction is provided on the various carding machines. The operators required to work inside the enclosures for maintenance and/or other work on the machines are required to wear Ori-nasal respirators. The cleaning of any fibre droppings inside the enclosure is done with the help of centralised vacuum collection system.

It was also noted that the card stripping operation is carried out using a totally enclosed stripping attachment connected to a high velocity suction unit. This arragement enables the card stripping operation to be carried out in such a manner where dust from the main cylinder of the card are collected into a bagging unit for easy disposal.

The carded sliver is then spun on spining frames which are provided with wetting roller arrangement so that the dust emanation is contained. The yarn so processed is in reasonably wet stage and not prone to release of dust. The spining frames at the time of doffing yarn are also cleaned any spillages with the centralised vacuum suction system. Further, the processing like plaiting, weaving are carried out in wet condition. The finished product, viz, cloth and plaited packings are finally dried before packing in polythene wrappers and water-proof packing paper. All the individual process machine work stations viz, carding, weaving and/or plaiting have been provided with dust collection arrangements which are connected to the centralised dust collection systems.

(c) **Medical Surveillance :**

The Company maintains extensive records of health status of its employees over several years including pre-employment records. These records include clinical examinations, chest X-rays and pulmonary function tests. All the employees of the company are periodically examined by the Company Medical Officer.

(d) **Environmental Surveillance :**

Dust level monitoring were also observed to be maintained by the Company at the various processing stations. They were also found to be well equipped in the areas of dust monitoring and measurement equipment.

The Company provides each of its employees with the twin locker facility, spaced well apart to store their street and work clothes separately.

5 **Asbestos Textile Plant : 26.3.85**

The Team visited an Asbestos Textile Plant at Bombay in the afternoon of 26.3.85.

The pre-packed asbestos bags are manually cut and fed into the Feed Hoppers of the blending plant and the blended fibres are conveyed pneumatically to the Card Hoppers. The exhaust provided at the hoppers appeared inadequate.

Carding machines are provided with plastic curtain enclosures. The system of curtains could have been improved with proper overlaps to avoid leakages.

A pit underneath the carding machines is used to collect droppings from the cards which was having considerable droppings which are reported to be periodically cleaned. Such an operation should be performed with personal protective equipment.

The Team also observed spinning and twisting operations where the yarn was being wetted before entering the spinning/doubling flyer. The Company has installed centralised vacuum system to periodically clean the frames.

Some of the sections of the factory were not working. Other operations, such as, weaving, plaiting etc. are located in another factory, which the Team could not visit.

The Team could not see any medical examination facility in this Company.

This is a small unit, with less than 150 workers.

The blending operation is done in a totally enclosed system and the blended fibres are then fed into the hoppers of carding machine by pneumatic conveying system.

Central vacuum and dust extraction plant is installed on a German dust extraction specialist design having a system of pipe lines reaching all the working areas of the factory premises. The pit in the carding is equipped with devices to extract and transfer the droppings pneumatically to the central vacuum cleaning plant. The dust extraction plant clears card stripping operation dust/fibre from the main cylinders and keeps the floor, machines, walls etc. clean of dust, fibre and droppings.

The management mentioned that operators are provided with Ori-nasal respirators. Airline respirators are also provided wherever exigencies of work so demand.

Workers are provided with two sets of lockers away from workplace.

DETERMINATION OF AIRBORNE ASBESTOS FIBRE CONCENTRATION IN WORKPLACES BY LIGHT MICROSCOPY (MEMBRANE FILTER METHOD)

1. Introduction

The airborne concentration of all types of asbestos fibres is determined by Membrane Filter M... but experience has shown that this method does not always produce comparable results when ... by different laboratories, and by different workers. These differences can arise due to ... sampling, preparation of sample, optical counting and other factors. The differences in results ... laboratories and counters can be minimised by strict adherence to these and rigorous quality ... procedures.

2. Scope and field of Application

This method applies to measurement of the number concentration of airborne fibres as ... counting criteria.

This method is applicable for routine sampling and sample evaluation necessary to asses ... exposure to asbestos fibres and their control in occupational environmen . It does not ... identification of composition or characteristics of particular fibres e.g. various ty... asbestos.

The use of this method has limitations when applied to samples containing platy or acicular p... and consequently should not be implemented without a full qualitative understanding of the ... There are a variety of methods available to determine composition of samples e.g. polariz... microscopy, electron-microscopy, X-Ray crystallography etc.

In this method all particles complying with the defined geometric conditions are, in abs... convincing information, to be considered as asbestos fibres and counted as such that under estimates of asbestos exposure are minimised.

3. General Method Description

A sample is collected by drawing a measured quantity of air through a membrane filter ... a battery operated sampling pump. The membrane filter is later transformed into ... optically homogenous specimen. The specimen is then examined under a phase cont... and the fibres are sized and counted. The results are expressed as number of fibres ... of air, calculated from the number of fibres on the filter and the measured volume ...

4. Sampling Apparatus And Technique

4.1 Filter

Membrane filters (mixed esters of cellulose or cellulose nitrate) ... pore size with 25mm diameter should be used

4.2 Filter Holder

It is necessary to use an open face filter Due to design of the filter support ... filter holders, a supporting pad of larger pore size, should be used. The purpose of ... pad is to ensure an even distribution of air passing through the primary membr... ities recommed open faced filter fitted with a protective metallic cowl. This helps ... filter from accidental damage and contamination But recent evidence suggests ... is unnecessary if proper care is taken, and use of cowl reduces collection effic... because of electrostatic charge it develops due to movement of air

4.3 Storage and Transport

The fixative must not be used.

Experience has shown that fixing fibre to the filter surface with cytological fixatives or other type of fixatives is unnecessary and should not be done.

The filters should be transported in closed holders, which should only be opened immediately before use and sealed immediately afterwards.

The alternative method is to transfer the filter to a petri-dish in the following way : In a dust free area, using forceps, carefully remove each used filter from its holder taking care to grasp it by its unexposed edge. Place the filter, dust side up, in a plastic petri-dish or similar container with one or two pieces of adhesive tape attached to the unexposed edge. After transporation, the filter can be easily removed from petri-dish with a surgical scalpel.

Pack the filter holders or petri-dishes into a rigid containers with sufficient soft packing material to prevent both crushing and vibration of the filter. The samples should be unambiguously labelled and caution is necessary to ensure that filters cannot be accidently reused. The filter surface should not be marked for the purpose because of risk of damaging the filter.

4.4 Sampling Pump.

A portable battery operated pump must be used for, personal sampling. The capacity of battery should be sufficient to operate continuously over the chosen sampling time. Thh flow must be free from pulsation.

As a minimum and tentative criteria there must be no visible vibration of a rotameter float when flow meter is connected to the filter holder. Although some pumps are equipped with pulsation dampers an external damper may have to be installed between the pump and the filter. Never run a pump without a filter. The connections should be leak proof.

Recent models of personal samplers have automatic flow correction devices. Such pumps should be preferred.

4.5 Flow Rate

The flow rate should be adjusted to 1 litre per minute (this gives approximately 4cm/second face velocity). The flow rate should be checked atleast before and after sampling; if the difference is greater than 10% from the initial flow rate, the sample must be rejected.

If an external flow meter is used to determine flow rate of the pump, care must be taken to ensure that the flow meter does not cause unknown changes to the flow rate. The flowmeter used should be able to measure flow rate to an accuracy within ± 5% of the true flow (95% confidence limit). (For flow rate calibration see Annexure I.)

4.6 Acceptable Fibre Loadings on Filters

4.6.1 Minimum Loading.

The minimum loading on filter should be 50 fibres/mm² (i,e. approximately 40 fibres per 100 Walton Beckett Graticule Areas). The lowering of the acceptable fibre loading gives better acceptable coefficients of variation.

4.6.2 Maximum Loading

The filter loading should not exceed a maximum of 650 fibre/mm² (5 fibres/graticule area) for majority of situations. The average filter loading exceeding 5 fibres/graticule area, tends to result in under estimation and should be treated with caution. This may have to be further reduced to an average of 1 fibre/graticule area when mixed dust agglomerates are present, and can sometimes be doubled if only fibres are present. Average filter loadings exceeding [illegible] fibres/graticule area must be rejected.

4.7 Blanks.

For each batch of filters used for sampling, and for every 25 filters in the batch, select [illegible] filter which has been subjected to the same treatment as for normal samples, but without [illegible] cap removed, having air drawn through it, or having been attached to the worker. If [illegible] yields fibre count greater than 3 fibre/100 graticule areas, the entire sampling and [illegible] procedure should be examined carefully to find the cause of the contamination. When the blank count exceeds 3 fibres/100 graticule areas and also exceeds 10% of the actual sample [illegible] graticule areas, the samples represented by the blank are not considered acceptable [illegible] of worker exposure. However, the determination may still be useful for indicating [illegible] with the hygiene standard (e.g. if the estimated exposure is less than that permitted [illegible] even with the contamination then this is a conservative estimate of compliance) [illegible]

For example : The fibre count of a blank filter was 15 fibres/100 graticule areas (i.e. [illegible] area) while the sample yields 108 fibres in 90 graticule areas (i.e. 1.20 fibres/area).

$$\frac{\text{Blank Count}}{\text{Sample Count}}\% = \frac{0.15}{1.20} \times 100 = 12.5\%$$

As this percentage exceeds 10, the sample is rejected. Furthermore, because the [illegible] exceeds 3 fibres/100 graticule areas the cause of contamination must be found and [illegible]

4.8 Recommended Single Sample Duration.

Taking into account the filter loading considerations as detailed in 4.6, the duration [illegible] single sample may be determined by application of the following formula :

$$t = \frac{A}{a} \frac{L}{\text{Cexp.}} \frac{1}{r}$$

t = Single Sample Duration.

L = required filter loading in fibres/graticule area.

A = effective filter area mm^2

a = graticule area mm^2

r = flow rate ml/min.

Cexp. = average fibre concentration expected to occur during the Single [illegible] (fibre/ml)

To provide guidance in the selection of single sample duration, the following table [illegible] ended single sample durations based on 2 fibres/graticule area. If it is not possible [illegible] values, the minimum and maximum durations allow a choice to be made whilst [illegible] within the constraints of 4.6. If the concentration is not known and the objective [illegible] sampling the Single Sampling Duration should preferably be that recommended for [illegible] limit.

	Single Sample Duration	
Expected fibres/ml.	t minimum (3)	t recommended (1)
0.1	3.3 hours	full shift
0.5	40 minutes	3 hours
1	20 minutes	1.5 hours
2	10 minutes	45 minutes
5	— (4)	20 minutes
10	— (4)	10 minutes
20	— (4)	10 minutes

Notes

1. : 2 fibres/graticule area.
2. : 5 fibres/graticule area.
3. : 0.4 fibres/graticule area equivalent to 50 fibres/mm^2.
4. : Sampling periods shorter than 10 min. are not recommended.

Sampling time should be measured within $\pm 2.5\%$. The timers or counters installed in some pumps are not always reliable.

4.4 Sampling Strategy and Records

The various types of sampling schemes are given in Annexure II with advantages and disadvantages. All data necessary for the determination of fibre concentration must be recorded along-with sampling details. An example of sampling and counting records is given in Annexure III.

5 Evaluation

5.1 Sample Preparation

5.1.1 Cleaning Slides and Equipment

Clean conditions should be maintained at all times.

A dirty preparation area may result in sample contamination and erroneous results.

Clean slides with lens tissue or industrial paper tissue and lay them on a clean surface, e.g lens tissue sheet. It is good practice to clean each coverslip with lens tissue immediately before use to ensure that the surfaces are free from contamination.

Wipe scalpel and forceps with lens tissue and place them on a clean surface, e.g. lens tissue. When mounting a series of filters, the mounting tools must be wiped clean before dealing with each sample.

5.1.2 Filter Sample Cutting

Mounting of the total filter is preferred. If it is necessary to cut the filter, all cutting should be done with a scalpel using rolling action. Do not use scissors. It is recommended that the smallest piece mounted be wedge-shaped, approximately one quarter or one third of the filter.

5.1.3 Mounting the Sample

For mounting use the acetone-triacetin method as described in Annexure-IV, unless a modified refractive index has to be used.

WARNING

Acetone mounting should be carried out only in a fume hood or fume cupboard. On no occasion should it be conducted in the vicinity of an open flame.

5.2 Optical Requirements

5.2.1 Microscope Equipment

The microscope is single most important equipment which can give marked variations in results of counting. Even microscopes of same make and identical specifications can give quite different performances. Thus it is necessary that performance of microscopes should be assessed by means of HSE/NPL Detection Limit Test Slide Mark-II (See Annexure V). Prorovided detection limit criterion is met, small departures from recommended specification can be permitted. It is also important for newcomers to consult experienced users before selecting microscopes for asbestos dust determination. The necessarys pecifications are as follows :

(*a*) *Light Source* : Koehler Illumination is required. A built-in illuminator is always preferable but an external lamp with a plain mirror can be satisfactory. A variable light intensity control is necessary for both methods of illumination.

(*b*) *Substage Assembly* : An Abbe or achromatic phasecontrast condenser incorporated into a substage unit is required.

There must be a means of centring each condenser annulus with respect to the phase plate in the corresponding objective and a means of focussing the condenser.

(*c*) *Stage* : A built-in mechanical specimen stage fitted with slide clamps and X-Y displacement is requied.

(*d*) *Objectives* : A rotating nose piece fitted with 10x and 40x objectives, must have numerical aperture (NA) of 0.65, achromatic. It should have a phase ring of not less than 65 percent and not more than 85 percent absorption. Although either positive or negative phase constrast is suitable but positive phase contrast is preferable because it gives brighter image.

(*e*) *Eye pieces* : Binocular eyepieces of compensating type are recommended. They should be chosen to give a total magnification of between 450 x and 500 x, preferably 500 x. Atleast one eye-piece must permit the insertion of a graticule and preferably be of focussing type.

The use of body magnification changers is not recommended.

(*f*) *Graticule* : The graticule recommended for this method is the Waiton-Beckett circular eyepiece graticule. Its actual diameter when using 40 x phase objective and appropriate eyepiece should be 100 um $\pm$ 2 um. (See Annexure VII).

(*g*) *Accessories* :

(*i*) *Centring Telescope or Bertand Lens*—is essential for checking that the phase rings in the condenser are centred with respect to those in the objective.

(*ii*) *Green Filter*—is necessary to ensure the best phase contrast conditions because the optics are designed for this wave length.

(*iii*) *Stage Micrometer*—must be subdivided into 10 um intervals and preferably be one millimeter long.

(*iv*) *Microscope Slides*—should be of the best quality.

(*v*) *Cover Slips*—of thickness to which microscope is designed are essential. Incorrect coverslip thickness will detract from the quality of the final image (Normally acceptable thickness of coverslip is 0.12 mm to 0.17 mm).

(*vi*) *Hand Operated Counter*—This should have two columns, one for No. of fibres and another for fields.

5.2.2 Microscope Adjustment Principles

Follow the manufacturer's instructions while observing the following guidelines :

(a) The image of the light source must be in focus and centred on the condenser iris or annular diaphragm for true kochler illumination.

(b) The object for examination must be in focus.

(c) The illuminator field iris must be in focus, centred on the sample and opened only to the point where the field of view is illuminated.

(d) The phase rings (Annular diaphram and phase shifting elements) must be concentric.

(e) The eyepiece graticule must be in focus.

(f) Before each counting exercise, the resolution power of microscope must be checked b detections limit test slide.

All microscopic adjustments must be a daily routine. (See Annexure VI for details).

Eyepiece Graticule Calibration

The combination of eye-piece, objective and graticule must be calibrated with a stage micrometer. Should any of the three be changed the combination must be recalibrated. For some microscopes, calibrations will change for observers with different interpupillary distances. (See Annexure VII).

Microscope Observer Performance Assessment

Because past experience has shown that significant differences in counts occur due to differences in microscope quality, setting up and cleanliness, it is necessary that laboratories following this method should maintain contact with those having experience with this method. The practical detection limit of microscope should correspond to Block 5 on HSE/NPL test slide Mark.II. Exchange of microscope slides for comparison with experienced laboratories will help to ensure that valid results are being generated.

It is desirable to determine intra-observer variation to assess reliability of an observer and in case, a laboratory employs more than one observer, intera-observer variation must be determined to standardize systematic variation in results.

Counting and Sizing Fibres

Low Power Scanning

Using a total magnification of 100x to 150x (i.e. 10x objective) scan the entire filter area. The area normally covered by the filter holder gasket should be free of dust and fibres. All exposed fields should have similar appearances with respect to total dust loading. If the observed fields show marked differences in loading or gross aggregation of fibres or dust, the filter should be rejected. The filter must also be rejected in case the background dust is high and interferes with counting and sizing of fibres or the filter shows any folds, kinks, or gross distortion due to improper mounting.

Counting Field Selection

After a satisfactory low power scan change the microscope objective to 40 x phase and focus on the dust plane. Ensure that the phase rings remain concentric. While most of the fibres and dust remains at the upper surface of the filter, it will be necessary to focus below (say upto 10 um) and slightly above the surface. When counting and sizing, constant use of the fine focus is necessary because of the small depth of focus of a 40 x objective (i.e. 2-3 um). Counting fields should be chosen at random throughout the entire area of the filter or filter segments. In case a grided filter has been used for sample collection and the grid obsructs the view the field should be rejected. Do not count fields that lie within 3 mm of the filter edge or within 2 mm of the cut edge.

Laboratory Working Conditions

The working practices and the working environment in a laboratory may influence systematically the accuracy of the actual counting. Some differences may appear when inter-laboratory comparisons are made which are due merely to different laboratory lighting conditions, different seating and computing arrangements etc. Different practices of recording data may also cause a lack of agreement between counters, due to the rate of fatigue of the eyes.

Interrupted writing of data involves the re-focussing of the eyes after each field, whereas continuous registering with electrical or mechanical counters involves only a single period of continuous concentration.

Counting Criteria

Designate all particles having the following geometric dimension as fibres :

- length greater than five micrometers and
- diameter less than three micrometers and
- length to diameter ratio greater than 3:1

Accuracy is important, and full use should be made of known dimensional standards. Estimate the length of curved fibres along the curve of the fibre (i.e. true length).

— When examined microscopically, asbestos fibres fall into four basic groups as follows :

  — Single fibres can be directly classified according to their geometric dimensions.

  — Split fibres are counted as one fibre, according to their geometric dimensions. The diameter of a split fibre is measured across the compact part of the fibre, not across the split part.

  — Grouped fibres are counted individually where individual fibres can be distinguished. Where they cannot be distinguished as individual fibres they are counted as equivalent to one fibre if the bundle has a total diameter less than three micrometers.

  — Fibre attached to particulate matter are counted as one fibre if the diameter of the particle is less than three micrometer, otherwise not.

  Refer to Annexure VIII for full details.

— The counting rules are based on the principle of counting fibre ends, visible within the graticule area and dividing by two to obtain the number of fibres observed.

  Count any fibre that lies entirely within the counting area. Count as 'Half Fibre' any fibre with only one end lying within the counting area.

  If a single curved fibre has each end inside the counting area having crossed the area twice, each end is still counted as half a fibre.

— Count as many fields as are necessary to give a total fibre count of 100. A minimum of 20 fields must be counted, even if more than 100 fibres have been observed. It is not necessary to count more than 100 fields. However, errors will be large when the minimum fibres or fields are not counted.

  All relevant information must be recorded. (See Annexure III for an example of a dust counting form).

5.4.0 <u>Calculation of Dust Concentration and Worker Exposure</u>

When the following calculations are applied, the limitation imposed upon the data by the sampling and fibre counting methods must not be disregarded. Results should not be interpreted or reported with false precision.

5.4.1 <u>Single Values</u>

The fibre concentration for each Single Sample Duration is determined according to the following formula :

$$c = \frac{A}{a} \cdot \frac{N}{n} \cdot \frac{1}{r} \cdot \frac{1}{t} \quad (1)$$

where

c = Concentration (Fibres/ml)

N = Total number of fibres counted.

n = number of graticule areas observed

A = effective filter area (mm^2)—See Annexure IX

a = Graticule counting area (mm^2)

r = Flow rate of air through filter (ml/min)

t = Single Sample Duration (Minutes).

5.4.2 Time Weighted Average Values.

When several samples of different sampling duration are taken, calculate the time weighted average values from the single values as follows :

$$CTW = \frac{\Sigma C_i\ t_i}{\Sigma\ \ t_i} = \frac{C_i\, t_i + C_2 t_2 + - - - - + C_n t_n}{t_1 + t_1 \quad + - - - - \quad t_n} \quad (2)$$

CTW = time weighted average concentration (Fibre/ml)

c_i = Single value of concentration (Fibres/ml)

t_i = Single sample duration (minutes)

Σ_{t_1} = Total sample duration.

n = Total number of samples.

If the single sample durations (ti) referred to above are of equal duration, then equation (2) is simplified as follows :

$$CTW = \frac{\Sigma C_i}{n} = \frac{C_1 + C_2 + - - - - - + c_n}{n} \quad (3)$$

5.4.3 Equivalent Eight Hour Exposure Value (Ceg.)

If the shift of the worker exposed to airborne asbestos dust is more than or less than eight hours, average concentration during the full shift must be multiplied by a factor (f) to yield the Concentration (Ceq) as follows:

$$f = \frac{\text{full shift time (hours)}}{\text{8 hours.}} \quad (4)$$

$$Ceq = f.\ CTW \text{ (full shift)} \qquad (5)$$

Example 1 :

Daily shift duration 12 hours ; time weighted average for the full shift of 1.2 fibres/ml.

Using equation (4) $f = \frac{12}{8} = 1.5$

Using equation (5) $Ceg = 1.5 \times 1.2 = 1.8$ fibres/ml.

Example 2 :

Daily shift duration of 5 hours with a corresponding shift average of 1.2 fibres/ml.

Using Equation (4) $f = \frac{5}{8} = 0.625$

Using Equation (5) $Ceq = 0.625 \times 1.5 = 0.8$ fibres/ml

This means that the worker was known to have zero exposure to asbestos outside of his 5 hour shift

5.4.4 Calculation of Ceq for Various Sampling Schemes.

Types — A, B, C and D.

1. Calculate single value concentration (s) for the sample (s) using equation (1).
2. Calculate time-weighted-average (CTW) concentration using the above single value (s) and respective single sample duration(s) in equation (2) (or (3), if applicable).
3. Calculat Ceq by using the procedure at 5.4.3.

5.4.3.2 **Calculation of Ceq for Sampling Scheme (E)**

Type 'E'

When 5 or more short term samples are taken randomly through out a full shift, the tim. weighted-average concentration can be estimated as follows :

1. Calculate the natural logarithm of each concentration

   $Y_i = \ln C_i$, i.e. $Y_1 = \ln C_1$, $Y_2 = \ln C_2$ and so on. if any concentration is less than 0.1 fibres ml, replace it with 0.1 fibre/ml for the above calculation.

2. Calculate the arithmetic average of the logarithmic concentrations.

$$\bar{Y} = \frac{\Sigma Yi}{n} = \frac{Y1 + Y2 + \text{-----} + Yn}{n}$$

3. Calculate the empirical logarithmic standard deviation (Se) of the logarithmic concentration(s) (sampling/analytical random errors and environmental fluctuations are included).

$$Se = \sqrt{\frac{1}{n-1}\left[\Sigma Y^2_i - \frac{1}{n}(\Sigma Y_i)^2\right]}$$

or

$$Se = \sqrt{\frac{1}{n-1}\left[Y_i^2 + Y^2_2 + \text{--} + Y^2_n - n(\bar{y})^2\right]}$$

4. The estimate of the average airborne concentration is calculated as follows ·

$$CTW - Exp\left[\bar{Y} - \frac{S^2_e}{2}\right]$$

NOTE : The above calculations are used because avalable evidence shows that random intra-day variations are best described by a log-normal distribution.

5. Using CTW from above, calculate Ceq as in Section 5.4.3.

5.4.3.3 **Calculation of Ceq for Sampling Scheme (F)**

Type – 'F'

1. Calculate single value concentration(s) for the samples using equation (1)
2. Calculate the items (Ti) for each individual working phase ensuring that the sum of these phase time equals a full shift.
3. Calculate the time-weighted-average concentration using the phase time (Ti) instead of the single sample duration (ti) in equation (2).
4. Calculate Ceq as in section 5.4.3.

NOTE : The above calculations for the different sampling schemes do not imply identical reliability in the estimation of the equivalent 8 hour exposure value (Ceq).

6.0 Sampling and Analytical Errors

6.1 General

Errors introduced into the estimation of airborne asbestos dust comprise sampling and analytical errors, each of which has a systematic and random component. The application of standard procedure and a reproducible routine is the only way of controlling most of the many sources of errors inherent in the membrane filter method. The following list describes some of the common sources of error.

6.2 Systematic Errors :

6.2.1 Sampling:

Flow rate
Sampling time
Non representative or biased samplings.
Contamination—deliberate or accidental

6.2.2 Analytical :

Effective filter area
Counting area
Counting criteria
Filter mounting
Microscope and observers
Contamination

6.3 Random Errors :

6.3.1 Sampling :

Flow rate variability.

Random fluctuations of the airborne dust cloud.

6.3.2 Analytical :

Fibre distribution on the filter :

Non-random deposition of dust on the filter leads to gross errors, the magnitude of which can not be estimated. Twenty or more fields must be counted to ensure that minor divergence from randomness does not bias the result.

Poisson errors:

As only small samples of the fibres deposited on the filter are counted, errors arise in the estimation of the total number of fibres on the entire filter face. Theoretically, the Poisson distribution defines the variation in fibre counts resulting from viewing randomly selected counting fields on the filter. If a minimum of 100 fibres is counted, and if a Poisson distribution is appropriate to the counting results, the relative standard deviation of the fibre counts would be ± 10 per cent. It has been shown experiementally that the actual distribution of fibre counts can depart from that of Poisson, in which case the standard deviation may be greater.

6.4 Overall Accuracy :

Because of the nature of the membrane filter method, it is not possible to know the true airborne fibre concentration of a given dust cloud. For this reason it is not possible to assess the likely accuracy of the method. Even the precision (or repeatability) of the method is difficult to quantify because of systematic errors which tend to arise from both intra and inter-laboratory variation.

Taken as a whole by "randomly" selecting observers and laboratories, these systematic errors take on random nature such that it may be possible in future to provide estimates of empirical precision (i.e. the closest approach possible to a statement of accuracy for a method with no known "true" values)

Much work has been done in an attempt to arrive at these estimates and todate only partial conclusions have been reached. One of these describes the theoretical Poisson distribution (See section 6.3.2) as contributing a 95% confidence interval of ± 35 percent for only 40 fibres counted in 100 graticule areas.

Other sources of random and systematic errors add significantly to the uncertainty in estimating the airborne asbestos dust concentration.

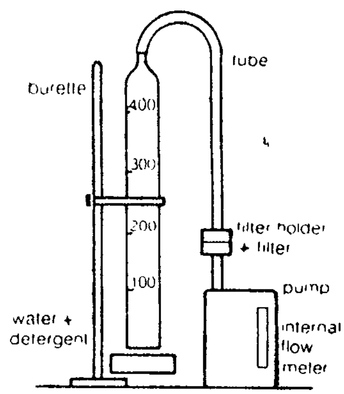
6.5 Limitations of the Membrane Filter Method And Presentation of Results :

With the parameters specified in this method, i.e. one litre/minute flow rate and a minimum filter loading of 15 fibres per 100 graticule areas, the theoretical lower detection limit for an eight hour sample is 0.02 fibres/ml; however, the practical limit is much higher. It is generally accepted that blank, unused filters can frequently give a reading of several countable fibres per 100 graticule areas. These fibres may be unidentified contaminents on the filter or artifacts from the clearing process which have the appearance of fibres. It must be recognised that neither counting more fields nor increasing sampling duration overcomes the problem of background dust, when asbestos is a minimum constituent in the overall dust cloud. There is at present insufficient information available to determine at what level the reliability of the method becomes so poor that results have little meaning. It is clear that this will not be a single value, but will be a range depending upon atleast the relative and absolute fibre concentration. There appears to be general agreement amongst those experienced in the field, that these limits lie somewhere in the range of 0.1 to 0.5 fibres/ml depending on a variety of conditions. In view of this situation, and the inherent variability of the method, all calculated values of less than 0.1 f/ml should be reported only as "less than 0.1 fibre/ml." All higher values should be rounded off to the first decimal place, and to two significant figures.

ANNEXURE I

FLOW RATE CALIBRATION AND CORRECTIONS

Internal and external flow meters must be calibrated with a primary calibration device. The method of calibration of the commonly used variable area flow meter (i.e. rotameter) using the soap film flow meter is given.



(a) Choose an accurate burette (or similar) of 300-1000 ml capacity. Attach a tube to the bottom of the burette, and then clamp it in an inverted vertical position into a stand.

(b) Set up the sampling pump complete with connecting tube, filter holder and filter as used in the field.

(c) Connect the soap film flow meter. Ensure that the system is leak proof. It is advisable to rinse the burette thoroughly in water immediately prior to the test-this removes accumulated detergent and also assists in wetting the inside of the burette.

(d) Switch on the pump and adjust the flowrate according to the internal flow mater (if fitted).

(e) Partly fill a beaker or petri dish with water plus the minimum amount of detergent necessary to permit bubbles to be formed.

(f) By momentarily placing the beaker against the bottom of the soap film flow meter create a bubble such that it will travel the entire length of the burette without bursting.

(g) With a stop watch, measure accurately the time that the bubble requires to traverse the tube between its extreme graduated ends.

(h) Repeat steps (f) and (g) at least twice, or more, until good repeatability of the times is achieved.

Average the times, and calculate the true flow (Qc) as follows :

$$Qc = \frac{V}{\tau}$$

Where Qc = True volumetric flowrate (ml/min.) at calibration conditions.

V = Volume of burette (ml).

τ = Average time required for bubble to traverse the tube (minutes).

Steps (d)—(i) must be repeated until the desired flowrate has been reached within 5 %.

NOTE – Theoretically, the water vapour content in the soap film flow meter air should be taken into consideration in determining the "true" flowrate. However, for practical purposes acceptable accurary is maintained without this correction.

(j) If the external or internal rotameter is used under different temperature conditions than those during calibration, it is generally not possible to calculate the different flowrate that will inevitably result.

As all air sampling measurements are connected only with volumetric flowrate (i.e. flowrate measured and expressed at the prevailling temperature and pressure) and not mass flowrate (i.e. flowrate corrected to standard temperature and pressure conditions), recalibration of the pump flowrate is essential if it is operated under conditions substantially different to those of calibration. Substantial implies a difference in altitude or temperature by more than 500 m or 15°C respectively compared to the calibration conditions.

Example : During the calibration of a pump with an internal flow meter a soap film flow meter of 1000 ml volume gave an average of 63.4 seconds for the bubble to traverse its length. What is the flowrate under these conditions? Using the equation in this Annexure :

$$Qc=\frac{V}{\tau}=\frac{1000}{63.4/60}=946 \text{ ml/min}$$

The flowrate, under the temperature and pressure conditions as stated above was 946 ml/min.

ANNEXURE II

EXAMPLES OF SAMPLING STRATEGY

E.1 Terminology.

E.1.1 Occupational Sampling

All sampling must be so conducted that the results are representative of the worker exposure to fibres under typical working conditions for a full shift. Sampling procedures must not interfere with the activities for the worker.

E.1.2 Worker Breathing Zone

In order to estimate worker exposure, samples must be taken in the workers' breathing zone.

The workers' breathing zone consists of a hemisphere of 300 mm radius extending in front of the face, and measured from the midpoint of a line bisecting the ears.

E.1.3 Personal Samples

Personal samples are taken within the workers' breathing zone. Usually the filter is fastened to the jacket lapel of the worker with the cowl pointing downwards. The worker carries the pump on a belt or in a pocket.

E.1.4 Static Samples

Static samples are samples taken at fixed locations with the cowl pointing downwards. They are not recommended for the measurement of personal occupational exposure to asbestos dust.

Point sources create considerable concentration gradients thus causing the results of static samples to vary considerably over short distances. However, static sampling can be useful if the dust is proven to be uniformly distributed over large areas.

E.1.5 Single Sample Duration

Single Sample Duration is the actual time during which a single sample is collected.

E 1.6 Total Sample Duration

Total Sample Duration is the sum of Single Sample Duration taken during one shift (see E.2.3) on one person.

E.1.7 Short Term Samples

The Single Sample Duration for a short term sample is less than one hour.

The short term sample has been defined because it is necessary to refer to that special case. Unless specified as short term, the samples are assumed to be of at least one hour duration.

E.2 Strategy

E.2.1 General Principles

Occupational exposure measurements are carried out to meet one or both of two major objectives :

(a) To assess exposure relative to an occupational hygiene standard and to enable better control measures to be implemented.

(b) To provide estimates of exposure for epidemiological investigations of morbidity and mortality.

It is well known that the concentrations vary widely both within a single day and from day to day. Most regulations and hygiene standards require a reliable estimate of exposure on a particular day. It is more useful for epidemiology to spread the sampling effort over a number of days, i.e, less will be known about a single day, but more about the average exposure over a working lifetime. Since sampling must often serve both purposes, the sampling schemes presented in this method comphasize the single day estimate. It must also be recognised that variations in individual working practices result in a distribution of exposure values within any job group. Consequently data from one person cannot be assumed to be representative of the total job group. Any transfer of data must, therefore, be validated by appropriate relative measurements.

E.2.2 Sampling Scheme

There are a number of possible sampling schemes, some of which are listed for guidance in the following table. As they very in the degree of usefulness and precision in estimating exposure, the table must be interpreted in association with the qualifying conditions and cautions presented in E.2.3 and E.2.4.

Sampling Scheme	No. of samples per shift	Total Sampling Duration
Long Term		
Full-shift consecutive sample (s)		
Type A	2 or more	approx. full shift
Type B	1	approx. full shift
Partial-shift consecutive sample(s)		
Type C	2 or more	2 hours or greater
Type D	1	1 hour or greater
Short Term		
Random Samples		
Type E	5 or more taken randomly throughout the working day	1 hour or greater
Systematic Samples		
Type F	1 or more plus continuous relative measurement, or 2 or more taken during each spearate phase of a cyclical operation	1 hour or greater

In planning a sampling scheme, it is important to determine :

* the Estimation Period during which the exposure is estimated.
* the total Sample Duration.
* the Number of Samples.

To assess the worker's full shift exposure every effort must be made to ensure that the samples relate to a whole working day. Care must be taken to ensure that the sampling period is not biased by abnormal conditions.

Short term samples should be taken at random (statistically) throughout the whole working day. If samples cannot be selected from the entire working day, the measurement results are valid only for the duration of the period from which the measurements were selected. However, relative measurements and reliable professional judgement can sometimes be used to make inferences about concentrations during other portions of the day. Reliable knowledge of the operation is essential to make such extrapolations.

E 2.3 Total Sampling Duration and Number of Samples

Sample duration is influenced primarily by the reason for sampling, the level of fibre concentration to be measured, the concentration of non-fibrous dust and the requirements of the analytical method. This may result in more than one single sample being required. The total sample duration should never be less than one hour.

4.6 and 4.8 detail acceptable minimum and maximum loadings of fibres on the filter, which dictate the range of possible sampling times for different airborne fibre concentrations. Samples of short duration may be necessary if high background levels of particulate matter or fibres are present which would prevent accurate analysis.

E 2.4 Reliability of Sampling Schemes

The main strength and limitations of the various sampling schemes, types A to F listed in E.2.2, are as follows :

(a) **Type A Sampling Scheme**

(two or more samples covering the full working shift) permits the most reliable estimate of exposure to be made. When several samples are taken, the average of the errors is usually less than the single (percentage) error in a single full shift sample. Occasional gross errors such as miscalculations, contamination, incorrect sample timing, etc. are more likely to be detected by type A than type B.

Note—Systematic errors, e.g. flowrate inaccuracy, must still be taken into account in the normal manner.

(b) **Type B Sampling Scheme**

(one full shift sample) is not as reliable as type A because gross errors can escape detection unless evidence from previous sampling is available on which to base a judgement.

(c) **Type C Sampling Scheme**

(two or more samples covering part of the full shift, i.e. two or more hours but less than full shift) can be satisfactory if the partial shift is representative of the full shift.

(d) **Type D Sampling Scheme**

(one sample, one or more hours but less than full shift) similar to type C except that gross errors may escape detection.

(e) **Type E Sampling Scheme**

(5 or more short term samples, taken randomly throughout the full shift) may give an acceptable indication of exposure but is generally more wastefull of resources and is the least precise of the above schems. Note that an even poorer estimate results when the "average" dust concentration increases or decreases markedly throughout the day. This scheme should be applied with caution.

(f) **Type F Sampling Scheme**

(several short term systematic samples taken during each separate phase of an operation) can be used by experienced industrial hygienists to characterise a workplace. This approach should not be used indiscriminately, particularly by peorsons not completely familiar with the process. Nor should it be used to estimate time-weighted -average exposure unless the results are verified by continuous relative measurements or other methods (see E.2.2).

ANNEXURE III

DUST SAMPLING RECORD

All data necessary for the determination of the fibre concentration must be recorded in a sampling record. Furthermore as much data as available which can be of value for epidemiological studies should be included.

Sampling Details

- ☐ Instrument Type and No.
- ☐ Flowrate, initial,intermediate and final
- ☐ Duration
- ☐ Sampling scheme used
- ☐ Date, Hour
- ☐ Sampled by

Sampling Place Details

- ☐ Designation
- ☐ Harmful substances-types of asbestos, quartz, etc.
- ☐ Brief description of working process
- ☐ Variable parameters which can excercise an infuence on dust formation
- ☐ Work practices
  - ... Working conditions : normal, abnormal
  - ... Material : type, size, conditions, etc.
  - : Airflow : worker in dust airflow yes/no obvious influence on adjoining working places.
- ☐ Methods of dutt control
  - : Exhaust ventilation
  - : Other methods
  - : Visual impression
- ☐ Number of employees for which the measuring value is representative
- ☐ Personal protection yes/no Type :
- ☐ Hours per shift
- ☐ Days per week

See the following page for Dust Sampling Record.

EXAMPLE ONLY

DUST SAMPLING RECORD

date

Place of measurement

Measuring point/Name — Code-No — text in clear block lettering

Dimension of workplace — $< 50\ m^3$ — $50 - 500\ m^3$ — $500 - 5000\ m^3$ — $> 5000\ m^3$

Exhaust ventilation — yes — no

Situation representative? — yes — no

Dust concentration — above average — below average

Visual impression — good — quite good — bad

Number of employees working at this working place ______

Respirators are worn — yes — no — sometimes — Type ______

Draught during measurement — no — yes — ______

Measured in the dustladen air flow — yes — no

Adjoining working places are influenced — no — yes — Measuring point No ______

Measurement was done — personal — static

Sampling device — atmospheric pressure — mbar

Air flow rate — time started — time ended

Sampling scheme used

Sample No	Sampling time (min.)	Total Flow	Working phase	Fibres/ml
			Average value	

Harmful substances — Chrysotile — Crocidolite — Amosite — Quartz — ______ (other) — Glass fibre — Mineral wool — ______

Appendix I

Dust Counting Record (Example only)

Counted by
Date
Microscope No
Graticule Type   Area   mm²

number of	
fibres	fields

0-bundles
X-background not okay

$$c = \frac{\Sigma n_f}{\Sigma n_{cf}} \cdot \frac{1}{V} \cdot F = \_\_\_\_\_\_\_\_\_\_\_\_ = \boxed{\quad} \ \frac{\text{fibres}}{\text{ml}}$$

In special circumstances it is of value to record the number of fibres contained in individual fields of counting

Example

n_f Sample No.

$$c = \frac{\Sigma n_f}{\Sigma n_{cf}} \cdot \frac{1}{V} \cdot F = \_\_\_\_\_\_\_\_\_\_\_\_ = \boxed{\quad} \ \frac{\text{fibres}}{\text{ml}}$$

c = concentration in fibres/ml
$N = \Sigma n_f$ = total number of fibres counted
$n = \Sigma n_{cf}$ = number of fields counted
A = effective filter area (mm²)
a = area of the counting field (mm²)
V = total flow (ml)
$F = \frac{A}{a}$ (constant factor)

ANNEXURE IV

ACETONE-TRIACETIN-MOUNTING PROCEDURE

The following is a description of a procedure for mounting membrane filters. The device is largely composed of parts available in chemistry laboratories. The handling of acetone requires great care in order to avoid accidents. Still safer devices are being developed. They may be used providing that the same slide quality (no washing off of fibres, smooth surface, clear background) can be obtained with them.

Warning

Acetone mounting should be carried out only in a fume hood or fume cupboard. On no occasion should it be conducted in the vicinity of an open flame. Only a small quatity of acctone is necessary. Heating with the waterbath is preferred, use of boiling chips in the acetone is recommended.

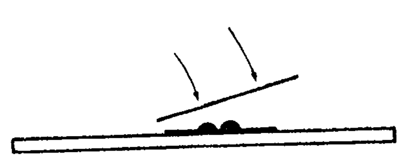
(a) As illustrated in the diagram below, it is advisable to use a simple condensing column to ensure that a bare minimum of acetone vapour escapes. The free opening in the tap must have a diameter of atleast 8 mm, otherwise the acetone vapour cannot escape in a sufficient quantity when using an open condensing column. When not in use, the acetone vapour outlet should be closed.

(b) Heat the acetone to boiling and wait until a moderate quantity of acetone vapour is emerging from the outlet.

(c) place the filter, dust side up, on a clean microscope slide at room temperature-electrostatic forces usually keep the filter on the slide.

(d) Ensuring that no liquid acetone drops on the filter (by wiping the outlet periodically with a tissue), hold the slide with clean forceps directly in the acetone vapour stream approximately 15 to 25 mm from the outlet for three to five seconds. At the same time move the filter slowly across the outlet to ensure even coverage until filter is transparent. Too little vapour will fail to render the filter transparent, while too much vapour (especially drops of liquid acetone) will destroy the filter by dissolvings it or shrinking it beyond use. The slide must not be prewarmed, as the acetone vapour must condense on the slide for correct clearing.

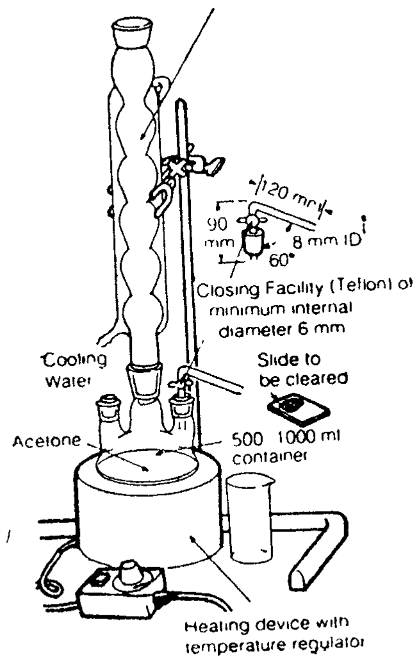
(e) Using a hypodermic syringe with a 22 gauge needle, place one to three drops of glycerol triacitate (triacetin) on the acetone cleared filter. To avoid the development of a "skin" over the triacetin, immediately lower at an angle (see diagram below) a clean coverslip onto the membrane.



(f) Too much triacetin (as indicated by excess liquid emerging from the edges of the coverslip) can cause the outside edge of the filter eventually to disintegrate to some degree. Insufficient triacetin will result in uneven clearing of the granularity left from the aceton vapour clearing. Further, the refractive index of the mounted sample will not be suitable for optimum visibility of very fine Chrysotile fibres.

(g) Heating the cleared filter to approximately 50°C for fifteen minutes accelerates the clearing process and enables analysis to proceed almost immediately thereafter. Otherwise it is necessary to delay counting for about 24 hours until the entire filter has dissolved under action of the triacetin. The finished product will be stable, will not disintegrate, nor be subject to particle migration.

(h) It is desirable to paint nail polish, or similar lacquer around the edge of the coverslip if the slide is to be kept indefinitely.



ANNEXURE V

HSE/NPL TEST SLIDE (MARK II) FOR THE DETERMINATION OF DETECTION LIMIT WHEN USING PHASE CONTRAST MICROSCOPY (1)

Description

The standard test slides consist of identical epoxy replicas (with a refractive index of 1.58) of a Master Slide produced and certified by the National Physical Laboratory (U.K.). The epoxy replicas are mounted on a glass slide 75 X 25 X 1.2 or 75 X 25 X 0.8 mm and covered by a coverslip 0.17 mm thick with a layer of another resin with a refractive index 1.49 in-between. The test objects consist of a series of 7 blocks of ridges of length 8.5 mm fillled with a resin of refractive index 1.49 in a medium of refractive index 1.58. The ridges have a V-shape profile and have a height to width ratio of about 0.1. The blocks are separated by gaps 20 μm wide. A set of 4 deep marker ridges is placed on either side of the array and a further two sets of 2 marker ridges spaced at an interval of 120 um intersect the array at right angles. The zone of the test objects to be usen is delineated by by the rectangle bounded by these marker ridges. This zone can easily be located as the field of view in which it is found, is engraved on the coverslip. This is illustrated in Figures I and II. The widths of the ridges within each block and the calculated phase change (in degrees) associated with the maximum path difference in light rays passing through the test objects are in Table I.

Method of use

Set up the microscope for phase contrast microscopy as recommended for the membrane filter method.

Locate Block I (the coarsest set) of the test objects and move the slide to observe adjacent blocks. Determine the block of the finest grooves that can be seen. It is unlikely that all seven blocks of grooves will be detected using optical phase contrast techniques, even on the best research microscope. On othe basis of present information, a satisfactory system will detect Block 5.

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(1) Available from: PTR OPTICS, Unit D9, Cross Green Approach, Cross Green Industrial Estate, Leeds, Yorkshire, United Kingdom, LS9 OSG

TABLE I

Widths of Test objects and Calculated Maximum Phase Change Induced in Light Rays passing through Test Objects of HSE/NPL Test Slide.

Block Number	Groove Width (μm)	Maximum Calculated Phase Change (in degress) for light rays $\lambda =$ 530 nanometres passing through test objects
1	1	6.6
2	0.77	4.7
3	0.64	3.9
4	0.53	3.2
5	0.44	2.7
6	0.36	2.2
7	0.25	1.5

Fig 1 Test slide (76 x 25 mm)

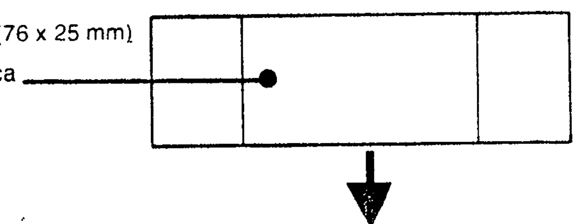
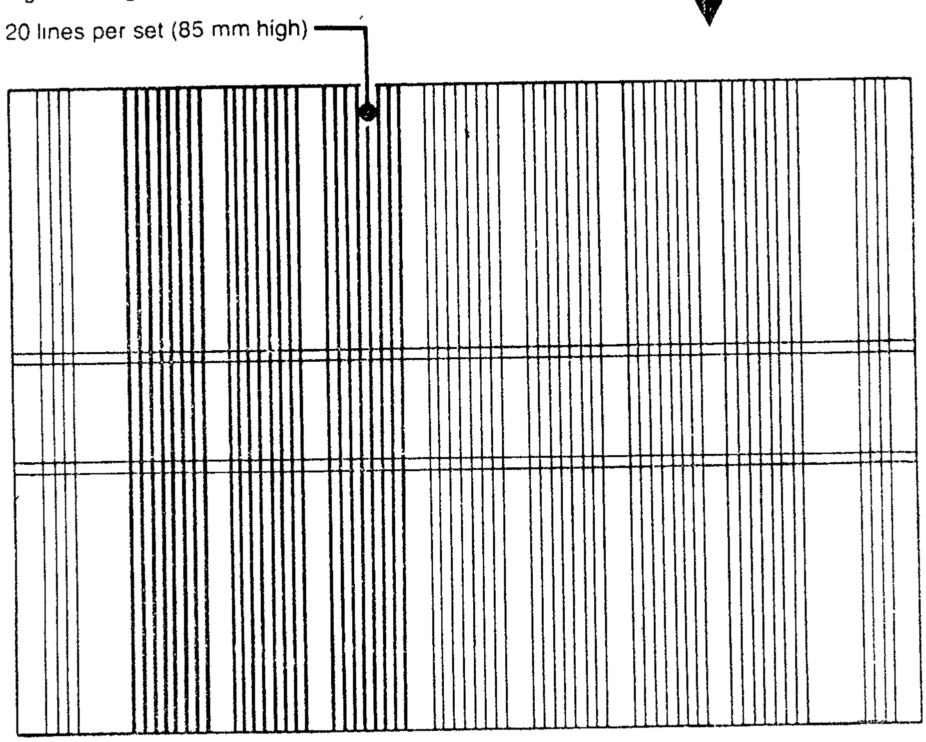


Fig 2 Enlarged field of view



ANNEXURE VI

MICROSCOPE ADJUSTMENT PROCEDURE

Good quality phase contrast microscope equipment should be used as detailed in 5.2.1. The equipment should be maintained in first-class condition and most manufacturers operate a routine maintenance service which includes the stripping down and cleaning of all optical components and the replacement of worn traverse mechanisms. Such services should be used unless skilled maintenance services can be provided by counting-laboratory staff.

In general the following setting-up procedure should be adopted to obtain Koehler illumination and good phase contrast conditions but the detail may vary according to manufacturer's instructions and the type of equipment.

(a) Place membrane filter specimen slide on microscope stage.

(b) Open both the illuminator diaphragm (often referred to as the field iris) and the substage condenser diaphragm. (Note—at this stage the phase annuli should not be inserted. These are usually based in a rotating drum fitted into the substage condensor unit.)

(c) Raise condenser to its upper limit, usually within 1 mm of lower face of specimen side.

(d) Using a convenient level of illumination and 10x objective focus the specimen.

(e) Close down the illuminator diaphragm and focus this in the field of view by lowering and raising the condenser. Centre the diaphragm and re-open to fill the field of view.

(f) Observe the back focal plane of the objective, using either a Bertrand lens fitted to the body of the microscope or by removing the eyepiece and using an auxiliary telescope.

(g) Observe image of bulb (removing the diffusing disc if one is fitted) and centre the bulb filament—focussing the bulb if possible with the adjustment provided. The image of the bulb filament should fill the back focal plane of the objective. Re-insert the diffusing disc if appropriate. (Note—if the bulb cannot be focussed adjust to give uniform bright illumination.)

(h) Insert the correct phase annulus into the condenser system and centre this using the appropriate adjusting screws so that the phase plate in the objective and the image of the annulus coincide exactly. Adjust slightly the condenser focussing if this is necessary. Ensure that the bright annulus image does not extend beyond the phase ring.

(i) Revert to normal viewing and change to 40x objective with no phase annuli in the condenser system. Close down the field diaphragm and refocus this by appropriate adjustment of the condenser. Re-centre if necessary and re-open to fill field of view.

(j) Repeat stages (f) and (h) after inserting the phase annulus appropriate to the 40x objective.

(k) Revert to normal viewing.

ANNEXURE VII

SPECIFICATIONS OF EYEPIECE GRATICULE, ORDERING INFORMATION AND CALIBRATION

The two sets of counting criteria specified in 5.3.4 include different limiting fibre aspect ratios viz. 3 : 1 and 5 : 1. The type G22 'Walton/Beckett' graticule (1) was designed for the 3 : 1 aspect ratio and has been available for several years. A modified version of this graticule has recently been designed specifically for the 5 : 1 aspect ratio (2).

For each graticule, the desired dimeter (d) of the circle to appear as 100 ± 2 micrometers in the object plane (D) of the graticule and the overall diameter of the glass disc should both be specified in millimeters before ordering. The following procedure is one of several methods for determining the diameter (d) of the circular counting area :

(a) Insert any available graticule into the eyepiece and focus so that the graticule grid is sharply in focus.

(b) Set the appropriate interpupillary distance, and if applicable reset the binocular head adjustment so that the "tube" length (and thus magnification) remains constant.

(c) Ensure that the 40× phase objective is in place, and that the magnification changer position (if used) is known and recorded.

(d) Place a stage micrometer on the microscope object stage and focus the microscope onto the graduated lines.

(e) Measure the overall object length (l_o) of the graticule grid using the stage micrometer.

(f) Remove the graticule from the microscope and measure its actual overall grid length(l_a). This can be done by using a stage fitted with verniers.

(g) Use the following equation :

$$\frac{l_a}{l_o} . D = d = \text{diameter to be specified}$$

Example : Step (e) produced an object length of a Porton graticule of 180 μm.

Step (f) produced an actural length of 4.50 mm.

$$\text{Step (g)} \quad \frac{4.50 \text{ mm}}{0.108 \text{ mm}} \times 0.1 = 4.17 \text{ mm}$$

It is also necessary to measure the overall diameter of the glass disc.

In this case the disc diameter was found to be 17 mm. Thus a "Walton/Beckett's graticule of disc diameter 17 mm and circle diameter 4. 17 mm should be specified for the above example.

CALIBRATION OF EYEPIECE GRATICULES

(a) Obtain a stage micrometer, prefeably with a scale having two or 10 μm divisions and, place on the object stage of the microscpe.

(b) Make sure interpupillary distance of eyepieces is set correctly.

(c) Note the objective magnification and any intermediate magnification used.

(d) Focus the microscope onto the stage micrometer.

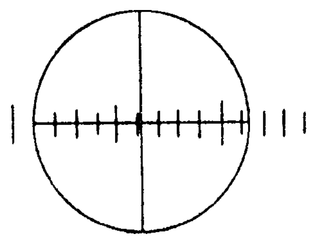
(e) Line up the eyepiece graticule with the graduated divisions on the micrometer so that the number of whole micrometer divisions can be counted from one side of the eyepiece graticule graduations to the other.

(f) If less than a whole division remains, estimate this fraction to the nearest micrometer and add to the number of whole divisions of the stage micrometer after converting to micrometer. This totalled result is the projected or object dimension of the eyepiece graticule.

Example :

(a) A stage micrometer with 10 um divisions was placed on the stage of a microscope.

(b) The following diagram depicts the view of the superimposed eyepiece graticule and stage micrometer.



Note that 10 whole divisions span across the graticule. i. e. 10×10 um.

(c) The remainder of the 11th division is estimated as being one third of a whole division, i. e. three um.

Adding these together yields 103 um which is the object dimension of the eyepiece graticule. Note that if the interpupillary distance, objective, intermediate magnification, or even in some microscopes the eyepiece is changed then this usually changes the object dimension of the eyepiece graticule-thus necessitating recalibration.

(1) Available from : Graticules Limited, Sovereign Way, Botany Trading Estate, Kent, England 1RN, Reference No. G22.

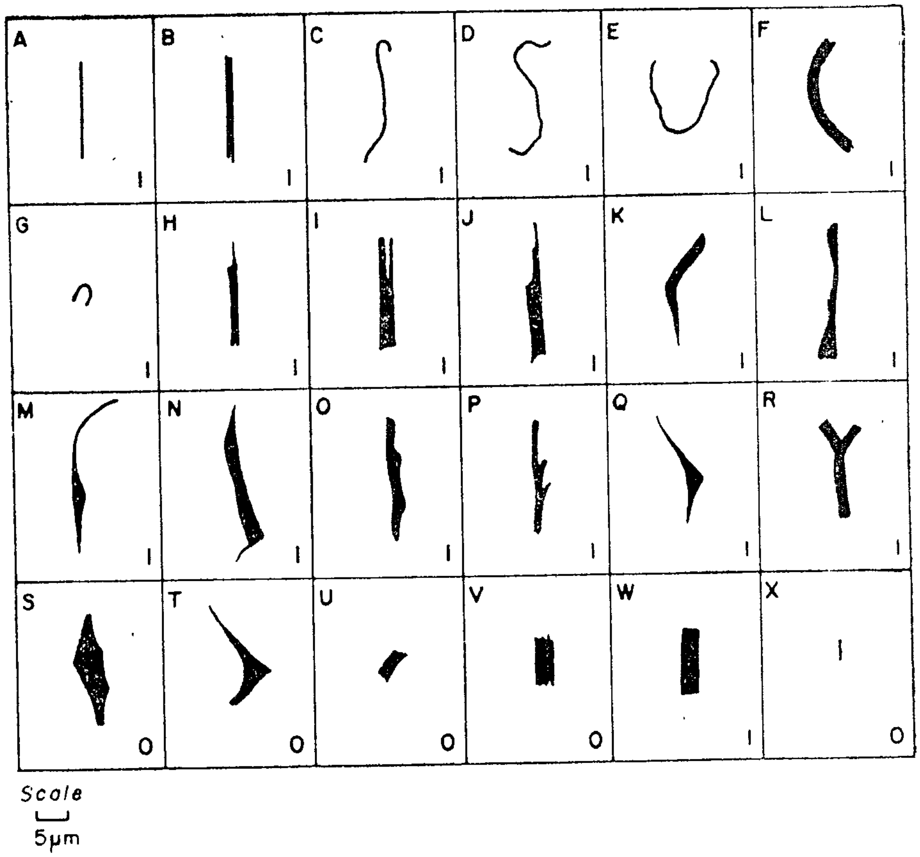
(2) Also available from Graticules Limited, but has yet to be assigned a Reference Number.

Drawings of Various Asbestos Fibres

NOTE: All drawings are the same scale i.e. one micrometer = 1 mm. The number in the right bottom corner of each drawing indicates the number of fibres (as defined) counted.

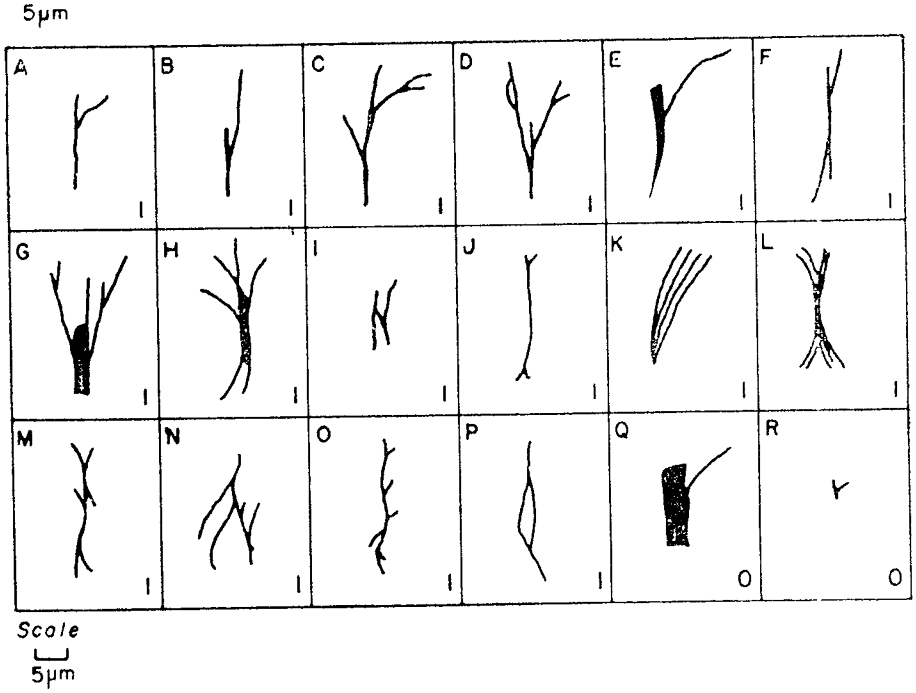
(a) **Single fibres**

These are the simplest of the fibres to identify and count. They are the most common of measurable fibres as seen on the membrane filter. Amosite and crocidolite fibres generally assume a straight needle-like form. Chrysotile fibres, while sometimes straight, often assume a curved or curly outline. Fibres which appear irregular and perhaps "unfibre-like" are counted if they conform to the basic requirements of fibre definition.



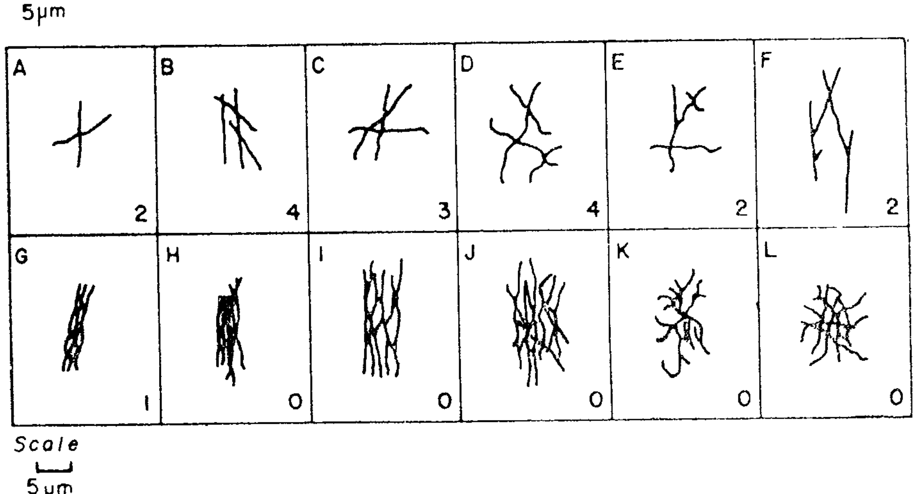
(b) **Split fibres**

These appear generally as a fibre or splitting away from a single stem.



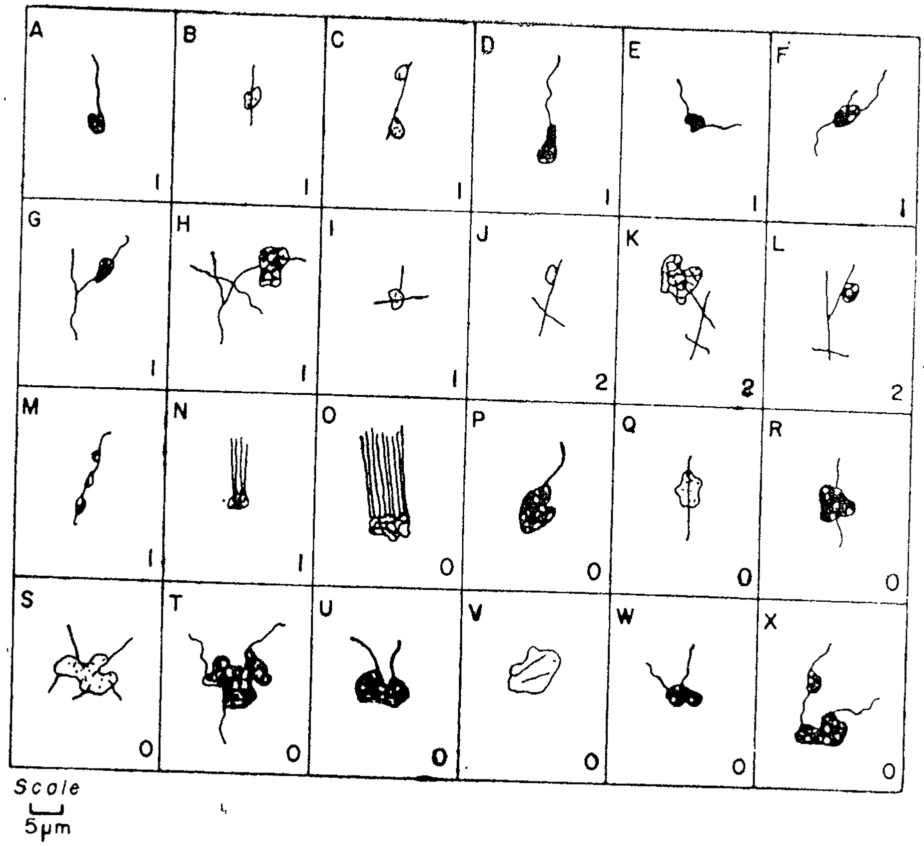
(c) **Grouped fibres**

These are formed when fibres overlap, intertwine or pack together. The simplest form is when two fibres overlap and cross each other. In this case each fibre in the group appears as a discrete entity. In more complex form fibres lie nearly parallel and appear to originate from the same bundle.



(d) **Fibres with other particles**

This group consists of fibres attached to, or embedded in particulate matter This latter material could be parent asbestos rock, or resins, cement, silicates, etc as used in manufactured products. Under the microscope some fibre, especially chrysotile, appears to project from the particulate matter with only part of the fibre seen. Other fibres (often amosite) are seen as embedded in the particulate matter.



ANNEXURE-IX

MEASUREMENT OF EFFCTIVE FILTER AREA

One convenient way in which to determine the area of the dust deposit (i.e. the effective filter area) is as follows :

(a) Place a small quantity of dark coloured fine dust (e.g. carbon, cement or road dust) into a 2 to 5-litre container with a lid.

(b) Shake the container, remove the lid and draw air through a membrane filter and its holder until the airborne dust in the container forms an obvious deposit on the filter.

(c) Remove the filter from the holder, and mount onto a microscope slide in the normal manner as described in the standard method.

(d) Measure at least four different diameters of the resultant dust spot to within ± 0.2 mm. Amongst other methods, microprojection measurement, or the use of microscope object stage verniers have been found satisfactory.

(e) Provided that the measured diameters differ by no more than 1 mm, a simple arithmetic average is sufficient to provide a good estimate of the effective filter diameter.

(f) At least three individual filters must be prepared and mean area calculated.

(g) Provided that the three filter diameters differ no more than 1 mm, an arithmetic average should be taken and the area calculated in the usual manner. This area is then the Effective Filter Area to be used for calculations in this method.

(h) If steps (e) or (g) produce differences greater than 1 mm, close attention should be paid to the sampling of the dust or to the filter clearing technique.

(i) It is necessary to repeat the measurement of the effective filter area if the type of filter or holder, or if any aspect relating to filter clearing is changed.

(j) It is advisable to repeat the entire measurement procedure every 12 months to ensure that the correct effective filter area is known.