# UPDATED VIEWS ON THE ASBESTOS FIBRE HAZARD

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SYNOPSIS

The high rate at which scientific publications on asbestos fibres roll off the press is mentioned. The main asbestos related diseases are stated and summaries are given of the harmful characteristics of fibres. The parameters to be measured, the airborne concentrations recorded and some observed disease responses are reviewed. A few risk estimates are related and the latest view on the hazard concerning ingested asbestos is quoted.

The airborne concentrational standards applied to working places are given and that recommended for the general atmosphere is mentioned.

*PREAMBLE*

Mining engineers play a *central* role in the field of dust exposure; central between medical men and dust physicists. The medical men tell us when persons develop diseases specific to a particular type of dust and the dust physicists design the instruments with which to measure the hazardous dust concentration.

The views expressed here are not necessarily my own, nor do they necessarily represent the official views of the Government Department with which I am associated. The views quoted are those expressed by medical men, scientists, epidemiologists, hygienists, engineers and others of international repute.

## 1. *INTRODUCTION*

During 1982 alone, no less than three international gatherings took place to discuss the asbestos fibre hazard. No wonder that asbestos fibre takes the first place in the current rate at which publications on a harmful airborne contaminant roll off the press. Testimony to this are the 147 sets of reprints totalling about 4 000 publications on the subject distributed since 1970.

> (The distribution is done by the Canadian Asbestos Information Centre (CAIC), previously done by the Institute of Occupational and Environmental Health (IOEH), Canada, on behalf of the Information Exchange System on asbestos and Health (IESAH) of the Scientific Committee on Mineral Fibres – of which the author is a member – of the Permanent Commission and International Association on Occupational Health (PCIAOH).)

Airborne quartz particles, responsible for silicosis, used to be the *number one* pollutant as far as the attention received from environmental hygienists were concerned, but asbestos fibre has now replaced quartz particles.

The three international gatherings on asbestos already referred to are the following:

1. World Symposium on Asbestos, 25-27 May 1982, Montreal Qué. CANADA.
2. Asbestos International Association (AIA)'s 4th Colloquium on dust Measurement Technique and Strategy, 20-23 September, 1982, Edinburg, SCOTLAND and
3. International Interdisciplinary Conference on Fibrous Dusts, their Measurement, Effects and Prevention, 4-8 October 1982, Strasbourg, FRANCE.

## 2. *DISEASES*

The diseases caused by airborne asbestos fibres are the following:

> Parenchymal fibrosis,
> bronchial cancer of the lung,
> malignant mesothelial tumour of the pleura and peritonium, and
> non-malignant pleural disease.
> (SLUIS-CREMER, private communication, 1983-05-02)

"Once established, some asbestos related diseases may progress even after exposure is terminated and no specific treatment exists. The latency period before initial clinical problems averages 10-20 years .... Lung cancer resulting from asbestos exposure has a latency period of 15 to 40 or more years .... mesothelioma is an otherwise rare form of cancer of the lining of the lung and abdominal cavity ..." (SELIKOFF, 1982).

## 3. *HARMFUL CHARACTERISTICS AND FACTORS*

To be harmful, a particulate must be of a size which permits it to be inhaled and retained in the lungs and it must be biologically active (WALTON, 1982).

"That long fibres are fibrogenic seems indisputable, but it cannot be said with any confidence that fibrogenicity

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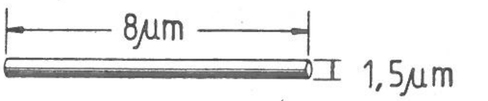
drops to negligible proportions at say 5 micrometres or 1 micrometre for that matter." (WALTON, 1982, quoting SELIKOFF and LEE, 1979).

For equal mass concentrations, short fibres have (by the Institute of Occupational Medicine, Edinburgh) been shown to be much less harmful than long fibres (DAVIS, 1982). "Hence, for equal number concentrations, the relative hazard for short fibres is even smaller" (WALTON, 1982).

To be CARCINOGENIC, a fibre MUST be DURABLE (at least as durable as chrysotile) it MUST be LONG (with a length of 8 micrometres or MORE) and it MUST be THIN (with a diameter of LESS than 1,5 micrometre) (Fig. 1). MOST HARMFUL are those LONGER than 20 micrometres and THINNER than 0,25 micrometre (POTT, 1982).

TO BE
CARCINOGENIC
A FIBRE MUST BE
(a)LONGER THAN 8μm &
(b)THINNER THAN 1,5μm




(1mm =1000μm )

FIG.1

Many people have a theory that it does not matter what a mineral or an artificial compound consists of provided that it is LONG, THIN and DURABLE. This theory, however, has not yet been proved.

Needless to say, the CONCENTRATION of the fibres is important. The higher the concentration one is exposed to, the higher is the hazard.

We have dealt with the physical characteristics of fibres as the first factor and their concentration as the second factor. The third factor to mention is TIME. Time enters the risk estimate TWICE. Firstly, it determines the total number of fibres inhaled as the product of time and concentration, namely, the DOSAGE. Secondly, and this is very important, the risk of developing mesothelioma increases as the 3rd to the 4th POWER of TIME SINCE FIRST EXPOSURE (PETO, 1982). Hence, the risk of developing mesothelioma 40 years after first exposure to any given fibre concentration, is 8 to 16 times the risk of developing mesothelioma 20 years after first exposure to that fibre concentration.

## 4. *PARAMETERS MEASURED*

"It is rarely possible to make an absolute measurement of that characteristic of an airborne dust which is directly responsible for its biological effect. To be practical, measurement for the purpose of assessing hazard, and evaluating control must not only be convenient and relevant, but it must also permit the use of statistically adequate sampling strategies .... Because of the variety of attributes, there could be as many as 100 indices of exposure to the asbestos in a dust cloud." (WALTON, 1982, quoting LYNCH et al, 1970).

For research purposes, fibres counted under the electron microscope should be cast into the size ranges given in the next figure (STÖBER, W., 1982).

The length ranges should be:

> 2,5 to 5 micrometres, 5 to 10, 10 to 20 and 20 to 100 micrometres, whereas the diameter ranges should be: Less than 0,5, 0,5 to 1,0 and 1,0 to 3,0 micrometres. (Fig. 2).

RECOMMENDED SIZE CLASSIFICATION
WHEN COUNTING FIBRES
UNDER THE ELECTRON MICROSCOPE

| MICROMETRES | | | | | |
|---|---|---|---|---|---|
| | | LENGTH | | | |
| | | 2,5-5 | 5-10 | 10 -20 | 20-100 |
| DIAMETER | 0,1-0,5 | | | | |
| | 0,5-1,0 | | | | |
| | 1,0-3,0 | | | | |

FIG.2

For routine control and comparative purposes, particulates seen at a magnification of 450 times under a phase contrast microscope should be counted as fibres IF they have:

a length of 5 to 100 micrometres,
a diameter of 3 micrometres or less, and
an aspect ratio (length ÷ diameter) of 3 or MORE.

These criteria are referred to as the asbestos fibre "counting package".

It should be pointed out that this COUNTING PACKAGE has now been in use since 1971 (PCIAOH, 1971). Suggestions to change it have of late been made and seriously considered at the Edinburgh Colloquium of 1982. One suggestion was to increase the lower limiting length to a figure of 10 or even 20 micrometres and another was to increase the aspect ratio to a figure of 5 or even 10. It was, however, decided not to do so at this stage in view of the repercussions this would have on comparisons between past and future records of fibre concentrations and in view of the uncertainties involved in establishing exact relationships between fibre dimensions and hazard.

For special purposes, such as for stack emission control, the mass concentration of total airborne asbestos dust has advantages over the number concentration of asbestos fibres. The number of fibres per unit mass of dust should then be determined if it has not already been done.

*5. CONCENTRATIONS RECORDED*

It is necessary to distinguish between the concentration of fibres in working places and that in the environment of the general population. It is also necessary to distinguish between short term (less than 8 hours) and long term (8 hours and longer) mean concentrations.

In the past, (i.e. many years ago) industrial working place short term fibre concentrations were hundreds of fibres per ml, in isolated instances even 1 000 and higher, whilst work place long term mean concentrations fell in the range 5 to 100 $fml^{-1}$.

The concentration in the general environment of certain parts of the world until recently was estimated to be of the order of 100 $fm^{-3}$ (0,00 1 $fml^{-1}$) (ROBOCK, 1981). In polluted areas, however, past concentrations in the general environment of some places were as high as $10^6$ $fm^{-3}$ (1 $fml^{-1}$).

*6. DISEASE RESPONSE*

The Montreal (May, 1982) Conference confirmed a number of the findings of the Ontario (CANADA) Royal Commission on Asbestos (September 1980). Some of the confirmed findings are the following:

1. "All human health effects of asbestos are dose-related (where "dose" is the product of time and concentration), and present – day health effects are attributed to high, often uncontrolled, exposures of the past."

2. "Asbestos exposures today are orders of magnitude lower than the historical exposures upon which knowledge of ill effects is based."

3. "Although the potential health effects of the lower exposure levels found in the work place today cannot be determined definitely, the best scientific evidence indicates that the risks are minimal if not insignificant."

4. "Even conservative overestimates of the health effects of asbestos at low exposure levels based on linear (non-threshold assumptions about the dose – response relationship) predict that properly controlled asbestos use today poses small, or well within acceptable level, occupational risks."

5. "Often expressed fears about asbestos risks to the general population have been widely exaggerated (in Ontario that is); no public health risks need exist from the continued proper use of modern encapsulated and locked-in asbestos products" (ONTARIO ROYAL COMMISSION, 1980) for example, asbestos cement.

These findings concern the Canadian situation and all of them do not necessarily apply to South Africa. Some, however, apply to asbestos in general and, therefore, do apply to the situation in South Africa.

To be specific, two investigations on South African amphibole (amosite and crocidolite) asbestos mines and mills revealed the following:

1. Amongst Caucasian (white) persons employed on crocidolite and amosite mines and mills on 30 November, 1970, the disease response was 8,5% with asbestosis (i.e. with an X-ray reading of 1/0 and higher) (SLUIS-CREMER and DU TOIT, 1973).

2. Among all men of white and mixed race in the employ of crocidolite and amosite mines and mills on 30 November, 1970, OR who had entered their employ between that date on 30 November, 1975, the prevalence of cases with an X-ray reading of 1/0 or greater for irregular opacities was 7,3%. The proportion with 1/0 readings or greater increased from 2,3% in men with exposure for one year or less to 26,7% in men with more than 15 years exposure (IRWIG, DU TOIT, et al, 1979).

## 7. *RISK ESTIMATES*

A number of estimates of the risk of asbestos related diseases have been made. An early estimate of the risk of asbestosis (where "asbestosis" was defined as "the earliest clinical demonstrable effects on the lung due to asbestos") was one per cent if exposed to 2 $fml^{-1}$ (of chrysotile fibres) for a working life of 50 years (BOHS, 1968). Another estimate amounts to 8,5 per cent with asbestosis (asbestosis diagnosed as an X-ray reading of 1/0 or more) under amosite and crocidolite mining and milling conditions at that time where the mean dosage of those with asbestosis was estimated at 396 $fml^{-1}$ – years (SLUIS-CREMER and DU TOIT, 1973).

A third estimate amounts to 7,6% with parenchymal abnormality (parenchymal abnormality being defined as: "irregular opacities with profusion 1/10 or greater") among persons exposed to amosite and crocidolite fibres under working nditions on asbestos mines and mills where 34% of the persons were exposed to a mean fibre level of less than 2 $fml^{-1}$, 35% to a mean fibre level between 2 and 5 $fml^{-1}$ and 31% to mean fibre level of more than 5 $fml^{-1}$ and where 48% of the persons had a mean exposure of less than 3 years, 42% had a mean exposure of 3 to 15 years and 10% an exposure of more than 15 years '(IRWIG, DU TOIT, et al, 1979)'.

The time since first exposure is very important with respect to the risk of developing mesothelioma. The USA mesothelioma death rate has been estimated" to rise as time since first exposure raised to the power 3,2, and for USA insulation workers first employed between 1922 and 1946, the annual death rate 30 years after first exposure is estimated at 2,3 per 1 000; the risk of dying of mesothelioma before age 80" is estimated at" 15% in men first exposed at age 20" (PETO, 1982).

Now turn to the risk in the general population. Estimates of the risk for the general population have been made. The accent has been on the risk of developing lung cancer and mesothelioma. The strategy has been followed of erring on the safe, i.e. on the high side. One estimate is that the incremental lung cancer deaths in 70 years per million exposed to a concentration of 0,02 $fml^{-1}$ (20 $fl^{-1}$) is 460 (ENTERLINE, 1981). Another estimate is that the mesothelioma risk after a life time of exposure to 1 $fl^{-1}$ (0,001 $fml^{-1}$) is one in 10 000 (i.e. 100 per million). This risk is of the same order as that "which non-smokers experience when moving from a small (European) town into a big city" (FISCHER, 1982).

## 8. *INGESTED ASBESTOS*

An updated view on the asbestos fibre hazard is not complete without a statement on ingested asbestos.

Probably more people ingest asbestos than inhale asbestos and much attention has been directed to possible dangers resulting from the ingestion of asbestos fibres in drinking water, in beer and even in wine filtered through asbestos containing filters. "Important research projects were embarked upon in Europe, Canada and the USA in order to assess the extent of the risks". The latest findings are as follows:

> "Animal feeding . . . . . . . . .as well as epidemiological studies have (all) proved negative . . . . . . No evidence whatsoever exists that ingested asbestos fibres in the concentrations possible in ordinary environments constitute a health hazard ...." (GLUCKMAN, 1983).

## 9. *THE CONCENTRATION STANDARDS APPLIED*

To date it has not been possible to demonstrate a fibre concentration at which there is no risk of disease after a total life time (70 years) exposure, or even of a working life time (50 years) exposure.

It is customary to signify a risk of less than one per cent after a working life of 50 years as an acceptable social risk, in other words, as a negligible risk.

A limiting concentration of 2 $fml^{-1}$ was, by 1968, estimated for chrysotile and amosite (BOHS, 1968). During 1970, "H.M. Factory Inspectorate, in a Technical Data Note (Department of Employment and Productivity, 1970) prescribed" a standard of 2 $fml^{-1}$ for chrysotile and amosite "but a more stringent one, namely 0,2 $fml^{-1}$, for crocidolite (when applying the British Asbestos Regulations – 1969). Supporting evidence for this discrimination was not given.

In contrast to this discrimination, the view that all types of fibre should have the same limit found general support at the 1982 Strasbourg Conference.

The current situation, however, is that different organisations recommend and/or apply different standards. The following are examples of the standards currently (1982) applied in different countries:

| *Country of Organisation* | *Standard* |
|---|---|
| France | 2 $fml^{-1}$ all types of asbestos |
| West Germany | 1 $fml^{-1}$ all types of asbestos |
| U.K. | 2 $fml^{-1}$ all types of asbestos except crocidolite for which the limit is 0,2 $fml^{-1}$. |
| American Conference of Governmental Industrial Hygienists. (ACGIH) | 2 $fml^{-1}$ chrysotile<br>0,5 $ml^{-1}$ amosite<br>0,2 $fml^{-1}$ crocidolite |

In practice, these standards are applied to factories, but not to mines. All over the western world the standards applied to mines are less stringent than those applied to factories or other working places on surface.

In Canada there are different standards in each Province varying from 2 to 5 $fml^{-1}$ with special (more lenient) regulations applicable to mining. The current South African factory* and mining standards both stand at 5 $fml^{-1}$.

South Africa is the first country in the world who decided to make a standard of 2 $fml^{-1}$ applicable to asbestos mines. This standard is due to be applied as from 1 January 1984.

When applying a standard, provision is usually made for the concentration stipulated to be exceeded for a time interval which is shorter than that to which the standard refers.

An interesting regulation which has become applicable of late (in Spain) reads as follows:

> "For periods of exposure other than 8-hours a day forty hours a week (when the standard is 2 $fml^{-1}$) the product of time and concentration shall not exceed 16" (S.M.E.S.S., 1982).

It is a general rule, however, that a concentration of 10 $fml^{-1}$ should not be exceeded at any time.

Legal limits for the general atmosphere have (to the author's knowledge) not yet been promulgated by any government, but it has been recommended (Fischer, 1982) that the limit should be 1 $fl^{-1}$ (i.e. 0,001 $fml^{-1}$ or 1 000 $fm^{-3}$).

*10. REFERENCES*


ACGIH, 1982: American Conference of Governmental Industrial Hygienists, Threshold Limit Values for 1982, 6 500 Glenway Ave., Bldg. D-5 Cincinnati, OH 45211, USA.

BOHS, 1968: British Occupational Hygiene Society, Committee on Hygiene Standards, Hygiene Standards for Airborne Amosite Asbestos Dust, Ann. Occup. Hyg. Vol. 16, pp 1-5 (1972).

DAVIS, J.M.G., 1982: Review of relevance of fibre dimensions, AIA 4th Colloquium on Dust Measurement, Technique and Strategy, Edinburgh 20-23 September, 1982. In the press.

ENTERLINE, P.E., 1981: Extrapolation from Occupational Studies, A Substitute for Environmental Epidemiology, Environmental Health Perspectives Vol. 42 p 39, 1981. – IOEH Code No. 5761 (142).

FISCHER, M., 1982: The Assessment of the Cancer Risk emanating from asbestos fibres by the German Federal Office of Health, Strasbourg Congress, 4-8 October 1982, In the Press.

GLUCKMAN, J., 1983: Asbestos in Drinking water, Editorial, South African Medical Journal Vol. 63 No. 7, (12 February 1983) p. 217.

IESAH-PCIAOH, 1982: Distributed to members of the Scientific Committee on Mineral Fibres of the PCIAOH by P.V. Pelnar of the Canadian Asbestos Information Centre.

IRWIG, L.M., DU TOIT, R.S.J. et al, 1979: Risk of Asbestosis in Crocidolite and amosite mines in S.A., Annals of the New York Academy of Sciences, Vol. 330 : 35, 1979, read with An Erratum in the press.

ONTARIO ROYAL COMMISSION ON: Matters of Health and Safety Arising from the Safe Use of Asbestos : Ontario Minister of Labour, September 1980.

PCIAOH, 1971: Fibres – Sub-Committee on Asbestosis of The Permanent Commission and International Association of Occupational Health (letter from Chairman of the Workgroup Lewis J. Cralley dated June 22, 1971 – GME 7/4/2/5).

PETO, J., 1980: Dose and time relationships for asbestos-related cancers, International Inter-disciplinary Conference, 4-8 October 1982, Strasbourg, in the press.

PETO, J., SEIDMAN, H., and SELIKOFF, I.J. 1982: Mesothelioma Mortality in Asbestos-Workers : Implications for models of Carcionogenesis and Risk Assessment, Br. J. Cancer (1982) 45, 124 – IOEH Code No. 5776. (142).

POTT, F., 1982 and ZIEM, U: Zur bedeutung von Länge und Durchmesser einer Faser für ihre kanzerogene Potenz, International Interdisciplinary Conference on Fibrous Dusts, 4-8 October 1982, Strasbourg, in the press.

ROBOCK, K., 1981: The Asbestos Problem Today IXth MEDICHEM Conference, ASWAN, EGYPT, 21-23 September 1981.

SELIKOFF, I.J., 1982: Disability Compensation for asbestos – associated disease in the United States, Environmental Sciences Laboratory, Mount Sinai School of Medicine of the City University of New York, 1982. (CAIC Code No. 520).

SLUIS-CREMER, G.K., and DU TOIT, R.S.J., 1973: Amosite and crocidolite mining and milling as causes of asbestosis, International Agency for Research on Cancer Scientific Publications No. 8, LYON, 1973, pp. 160-164.

S.M.E.S.S., 1982: Spanish Ministry of Employment and Social Security, Reference No. 20507 of 21 July 1982.


*I.M. Mulder, private communication, 1983-05-03

STÖBER, W., 1982: Einfürung in die Problematik der Fasermesstechnik, Strasbourg, 408 October 1982, in the press.

WALTON, W.H. (1982): The nature, hazards and assessment of occupational exposure to airborne asbestos dust: A review. Ann. Occup. Hyg. Vol. 25, No. 2.

WALTON, W.H., 1982: Discussion on Davis's paper on the Relevence of fibre Dimensions, Edinburgh, 20-23 September 1982, in the press.

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