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UC-1378

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Asbestos as a Health Hazard in the United Kingdom

by

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1967

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SUMMARY

This report has been written to show the concern on toxicological grounds of those people involved with asbestos in the U.K.

Descriptions are given of the attitudes of the various industries approached. Action taken by Union Carbide U.K. personnel is recorded. Up to date information is presented, and its implications are discussed.

Attention is brought to a formal request made by the Pneumoconiosis Research Unit, Penarth, S.Wales, for assistance with their research programme. The recommendation is made that Union Carbide should offer its facilities for trace element analysis of the five Standard Samples, assembled under the auspices of the U.I.C.C.

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ASBESTOS AS A HEALTH HAZARD IN THE UNITED KINGDOM

1.0 INTRODUCTION

Union Carbide U.K. Limited has been promoting the sale of Coalinga asbestos for just over two years. During this time, the public has become increasingly aware of the considerable health risks associated with the use of this material. This has come about with a mixture of both good and misleading press articles, and in January, interest was accelerated by a provocative television programme in which Blue asbestos was spectacularly condemned.

So far, over 20 potential customers have raised the issue, and have requested an assurance that Carbide's material will not be a source of danger to their employees. Some have even refused to consider a laboratory evaluation until the matter becomes satisfactorily resolved. It is felt that an intensification of activity by the Factory Health Inspectors as well as potential Union objections are the prime reasons for the reluctance.

Carbide's replies have been based upon the two communications sent from New York Office on March 22nd, 1966, and October 7th, 1966, as well as Dr. Dernehl's "Asbestos Toxicology Report". These have gone part-way in alleviating some of the anxiety. However, there is a growing feeling that the quoted "Threshold Limit Value" is no longer tenable. This, coupled with the overall lack of positive knowledge, still makes the whole situation manifestly unsatisfactory. With this in mind, it was thought opportune to review the action taken to date by Union Carbide U.K., and present a survey of the information gleaned from several sources.

2.0 HISTORICAL SUMMARY

2.1 General

It is possible that public interest was initiated in Great Britain by an article in the Sunday Times (31st October, 1965) which summarised the work of Newhouse and Thompson at the London Hospital. These two workers had conducted an epidemiological survey on 83 patients admitted to the hospital over approximately 50 years. Each patient (41 male and 42 female) had positively diagnosed diffuse pleural or peritoneal mesothelioma. Evidence of exposure to asbestos was obtained in 40 of the 76 cases whose background histories could be accurately traced.

It was also in this article that the description was given of a docker's wife who died of mesothelioma, and whose only contact with asbestos had resulted from washing her husband's overalls. This example has become a cliché, and is now cited by all opponents of asbestos usage.

Factories in the U.K. are at present governed by outmoded Asbestos Regulations promulgated in 1931. Realisation that they are not entirely effective was brought about by figures published by the Ministry of Pensions and National Insurance. These show that there has been an overall decrease in the number

of new cases of most types of pneumoconiosis, but for asbestosis the trend is still upward. Shown below are the number of diagnosed asbestosis cases over the years 1960-64.

	1960	1961	1962	1963	1964
Number of Cases	29	43	52	67	83

The Ministry of Labour is now actively engaged in formulating a new code of regulations, which this time will be more stringent and will include pipe laggers and dockers, both of whom were excluded in 1931.

To date, about 500 cases of cancer of the lung and mesothelioma are known to have occurred among people exposed to asbestos dust in the U.K. This may seem surprisingly small when it is realised that 25,000 cases of carcinoma of the lung - largely due to smoking - are diagnosed in this country every year. It is pointed out, however, that it is only recently that close attention has been paid to the problem. It is therefore inevitable that an unknown number of cases has escaped detection.

2.2 Paper

Only 3 or 4 mills in the U.K. are bona fide asbestos users. Probably with these mills specifically in mind, the Paper and Board Makers Federation sent a circular to its members last year. This stated that the Minister of Social Security had made regulations (invoked in 1966) which allowed for compensation to be granted to persons suffering from a number of prescribed diseases. One of these was "diffuse mesothelioma".

This publication caused a number of questions and doubts by several mills engaged in the evaluation of High Purity asbestos. The following examples exhibit the approach to the problem taken by some of the British mills.

2.2.1. Southalls. - makers of cellulose wadding for sanitary applications. This was the first mill to challenge our material from a toxicological standpoint. They ran a 2-day trial at the end of 1965, and showed some technical advantages. They refused, however, to proceed further as they calculated that there would be at least 2 lbs. of airborne asbestos produced each day at the creping doctor.

2.2.2. Charles Turner. - rival of Southalls. Also worried by dust hazard at creping doctor and cutters.

2.2.3. Tullis Russell. - the laboratory personnel were advised to wear masks when evaluating High Purity asbestos. Nevertheless, failure to run a trial so far is probably attributable to indecisive experimental work rather than trepidation as to toxic hazards.

2.2.4. Dartford Paper. - ran a trial a few days after the damning television broadcast. The mill safety officer was present, and asked several (mainly unanswerable) questions, as did a number of the operatives. Present mill policy is to run the next trial when the subject has been 'forgotten'.

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2.2.5. Reed Group. - showed concern 9 months ago. Their Medical Officer consulted the Chemical Health Officer and sent a letter to Imperial mill, who were intending to use asbestos. He stated that in his opinion, the amount of asbestos used (less than 2% in the sheet) was too small to be a hazard to health.

2.3 Other Applications

Market development in fields such as caulks, sealants, mastics, adhesives and polyesters is still in its infancy, and is currently very active. For these applications it has been necessary to offer the open grade products, because few manufacturers have sufficiently high shear devices to liberate the compacted pellets.

All manufacturers are aware of the probable toxic hazards, especially those already utilising asbestos in some of their products. Reaction varies, but it would seem that more objections and refusals to go further have been obtained from the larger firms. This is most likely due to a greater frequency of visits by the Health authorities, and also to more organised union activity.

I.C.I. are tightening up their procedures concerning asbestos. Their laboratory personnel have been instructed to wear masks when dealing with the material.

The technical section of Dunlop Chemicals is very worried by the management proposal that all asbestos should be eradicated from their works.

British Paints report that the factory inspectors have recommended, and will eventually insist on, costly extraction equipment for those departments dealing with asbestos. The technical personnel have stated that there is no substitute for the fibrous material, and they envisage that a compromise will have to be made.

2.4 Dockers

Until the last few months, asbestos was imported into the U.K. in hessian bags. Probably as a result of the television programme, the London dockers are now refusing to handle asbestos until the consignments are properly packed in indestructible containers. This attitude has now spread to other ports. For example, less than three weeks ago, a dispute arose at Liverpool docks over a cargo of asbestos. 900 men were involved, and even after the employers had offered to supply masks and overalls, together with additional pay rates, the dockers refused to work the cargo until it was 'properly' packed. It is believed that only three ports are now open to the passage of the material. They are Bristol, Hull and Manchester.

3.0 ACTION TAKEN BY UNION CARBIDE

3.1 Visits

Three informed sources have been approached since September, 1966. They are:

3.1.1. Chemical Inspector of Health, Baynards House, 1-13 Chepstow Place, Westbourne Grove, London. Contact: Mr. R. Walpole.

This is the headquarters and reference centre for the regional factory inspectors. The outcome of the meeting was a confirmation that the 5,000,000 particles per cubic foot threshold limit is currently adhered to in Great Britain. It is expressed over here as 176 particles per c.c.

3.1.2. Asbestosis Research Council, P.O. Box No. 40, Rochdale, Lancashire. Contact: Dr. S. Holmes.

This is a body set up by the three biggest asbestos companies in Great Britain. It is primarily concerned with minimizing the asbestos dust atmospheres in their factories. Their ambitions seem to have been almost fulfilled. Turners of Rochdale claim to have had only 3 deaths attributed to asbestos since 1881. They believe that these were the result of the last war when their operators were working long hours under blackout conditions, and when a quantity of Crocidolite was used. This material had not been used before the war, nor has it been used since.

Dr. Holmes mentioned an item of great interest. Apparently, some types of masks used to protect workers from asbestos and other dusts, do themselves contain Crocidolite as the filter medium. Turners have experimented with them, and have found that it is possible to inhale an extremely high concentration of asbestos in a short space of time.

3.1.3. Pneumoconiosis Research Unit, Llandough Hospital, Penarth, Glamorgan. Contacts: Dr. V. Timbrell, Dr. A. Walters.

This unit is a branch of the Medical Research Council. It was originated initially to study the effects of coal dust in the lung. It is also associated with the U.I.C.C. (Union Internationale Contre Cancer).

The group consists of about 12 competent men, among whom Drs. Gilson, Wagner and Timbrell are world authorities. They are currently attempting to seek a solution to the problem of the aetiology of mesothelioma, and also to discover whether only one type of asbestos is responsible for the development of these tumours.

3.2 Dockers

Three courses of action have so far been taken:

3.2.1. Meeting with the Shipowners and Dock Labour Committee, Union Carbide being represented by Messrs. Cheston, Sayers and Sly. The purpose was to acquaint the dockers with our pelletised product, and to learn what form of packing was most acceptable to them. The outcome of this meeting has already been described in a report by Mr. P. R. Cheston on 16th February, 1967.

3.2.2. Messrs. Cheston and Sly were present at the unloading of 50 tons of Union Carbide High Purity pellets from the s.s. Bolinas. A description of the consignment's condition and the subsequent difficulty encountered in persuading the dockers to work it have already been reported by Mr. Sly.

3.2.3. Designs of a new and stronger pallet have been sent to New York and King City. Negotiations have also been conducted with several shipping lines who specialise in container transport. One particular company has offered favourable rates which should enable material to be delivered to London docks at a viable cost and in a manner which will be completely acceptable to the dockers.

3.3 Literature Surveys

These are made from time to time on the subject of toxicology, and a number of the more important articles have been collected.

4.0 INFORMATION ACCRUED

4.1 Diseases Associated with Asbestos

Three diseases are believed to be caused by the inhalation of asbestos into the lungs. They are:

4.1.1. Asbestosis.

4.1.2. Bronchial carcinoma.

4.1.3. Mesothelioma of the pleura and peritoneum.

Evidence is now growing to indicate that there is also an increased incidence of cancers of the gastro-intestinal tract. It has been suggested that asbestos fibres may migrate from the lung, but there is also the possibility that they may be swallowed direct (ingestion of bronchial secretions). Support for the migration theory has been strengthened by the discovery of asbestos fibres in the liver and spleen.

4.2 Asbestosis

4.2.1. Nature of Disease: This disease, which appears to result from long exposure to asbestos dust, is similar to the well defined complaint, silicosis. The dust particles stimulate the proliferation of fibroblasts, which produce a slow, insidious, low grade, progressive fibrosis, which commences in the region of the bronchioles. This causes a thickening of the bronchiole wall and the pleura, but in its early stages, the lesion is not obstructive. As fibrosis develops, however, the whole lung becomes scarred, so that the oxygen/carbon dioxide interchange between the air and the blood is impeded. This causes an extra burden on the heart, which may prematurely fail under the strain.

The final stage of asbestosis is the formation of the 'asbestos body', which is believed to be a Ferritin envelope (Ferritin is an iron-protein complex which contains about 20% iron) surrounding

the asbestos fibre. This is laid down in concentric rings. The Ferritin material is a normal body constituent, and the iron component is believed not to be derived from the iron present in asbestos.

4.2.2. Mortality Rates: Examination of the figures covering the two periods 1931-46 and 1957-64 reveals that there has been no striking change in the years of exposure or duration of illness in the deaths from asbestosis. There has, however, been a marked change in the average age at death - a rise of nearly 10 years in men and 20 in women. (This increase has been attributed to a virtual elimination of tuberculosis in the U.K. in recent years.) In 1964, the average age at death was 57 years, but even so, subjects who had been under heavy exposure to asbestos were dying in their 30's and 40's.

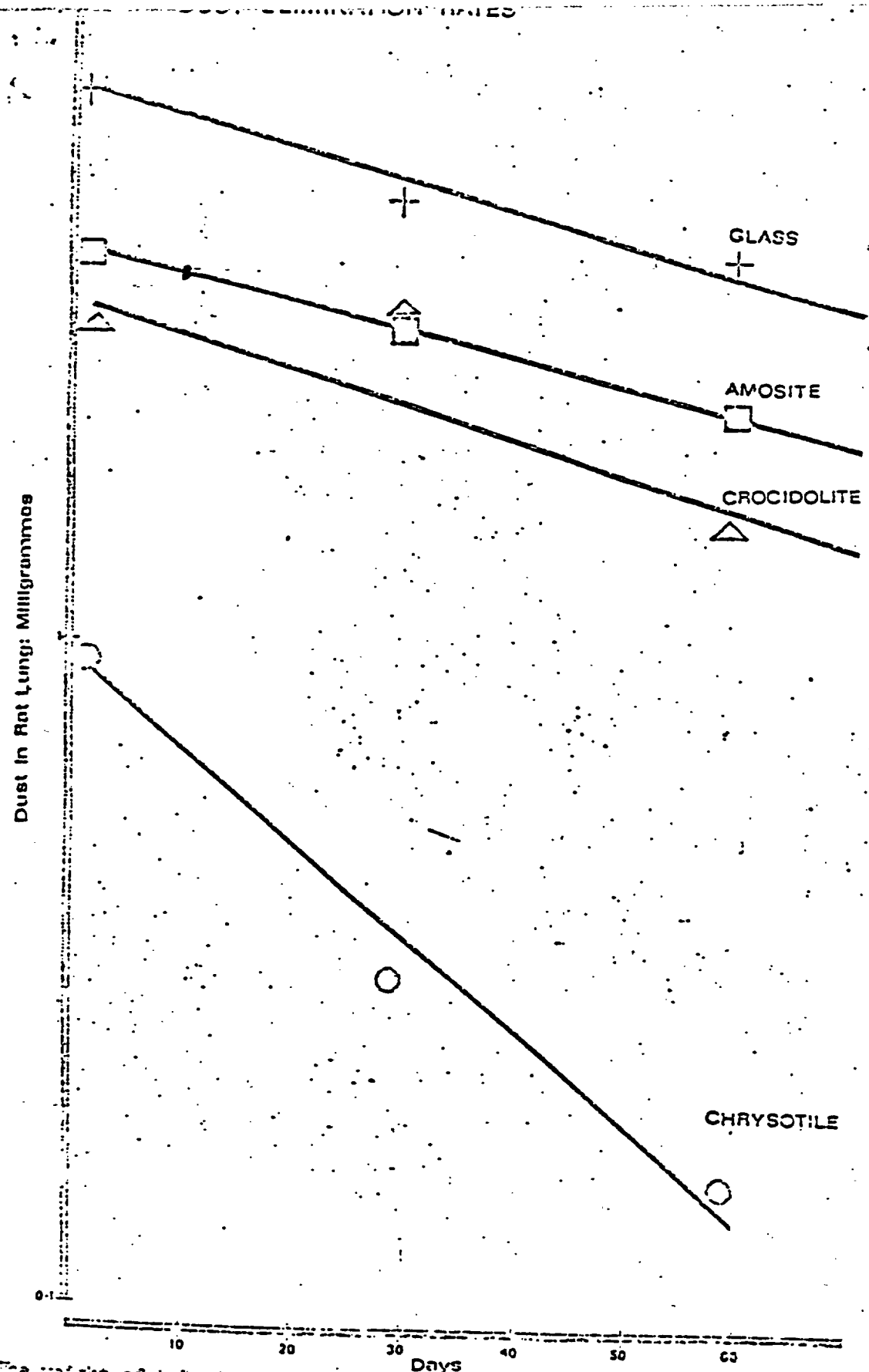
4.2.3. Experimental Work: Quantitive inhalation experiments on animals are now being carried out by Wagner et al. They have already shown that Chrysotile produces less fibrosis than Amosite or Crocidolite for the same dose by inhalation. This appears to be due to a more rapid elimination of the Chrysotile, probably due to a solubility effect. Figure 1 shows the results of giving equal doses of Chrysotile, Crocidolite, Amosite and finely powdered glass to rats by inhalation. Each point on the graph is the mean of 8 rats, (equal numbers of male and female).

The importance of particle length in the development of fibrosis is still not solved. Wagner has shown that in several animal species, fibrosis of the lungs is produced by fine particles or very short fibres. It is believed that long fibres may still be more fibrogenic for a given mass than short ones.

4.3 Bronchial Carcinoma

4.3.1. Nature of Disease: This is the same type of cancer as that produced by cigarettes, and it is now accepted that asbestos also predisposes to this condition.

4.3.2. Mortality Rates: The proportion of asbestosis death certificates which also record a thoracic tumour (lung cancer), has risen in both sexes disproportionately to the number of uncomplicated cases of asbestosis. Currently, over 50% of males dying with asbestosis also have a neoplasm. Even when viewed against the steadily rising incidence of lung cancer in the population as a whole, there seems little doubt that the increase is a real one. Evidence of this is shown below in Table 1:



g.1: The weight of asbestos dust and powdered glass in rats' lungs after 30 days' exposure to groups of similar respirable mass concentration, and the subsequent loss of dust over the 30 days. Each point is the mean of 8 rats (equal numbers of male and female).

Period	MALES			FEMALES		
	Asbestosis all deaths	Asbestosis with lung cancer	% with cancer of lung	Asbestosis all deaths	Asbestosis with lung cancer	% with cancer of lung
1924-30	13	-	NIL	7	-	NIL
1931-40	66	13	19.7	82	5	6.1
1941-50	92	21	22.8	45	5	11.1
1951-60	144	45	31.3	40	11	27.5
1961-64	113	62	54.7	26	7	26.9
1924-64	428	141	32.9	200	28	14.0

Table 1

4.4 Mesothelioma

4.4.1. Occurrence of Disease: Mesothelioma is the most disturbing of the three diseases attributable to asbestos for two reasons. Firstly, in contrast to bronchial carcinoma, it can occur in people with minimal fibrosis, i.e. only after a brief exposure, which may be as little as three months. Some authorities even believe that a single brief exposure might be sufficient.

Secondly, there is a very long time lag between the original exposure and the clinical appearance of the cancer. Thirty years is estimated to be an average time.

4.4.2. Cause of Disease: The most up to date information on the likely agent responsible for this type of pleural neoplasm was presented in a press hand-out issued by Dr. Wagner in February of this year. He wrote:

> "On current evidence from South Africa, Australia and Britain, it would appear that Crocidolite is mainly implicated in the development of mesotheliomas. However, cases have occurred in the U.S. (16 in number between 1963 and 1965) Canada (6 in number, 1952-1964) and a few in Britain, in which people concerned appear to have only been exposed to Chrysotile."

At present in South Africa a continuous search is being made to detect any cases of mesothelial tumour coming from the Amosite and Chrysotile mining areas; so far, none has been discovered. This search has also been carried out in Czechoslovakia where only Russian Chrysotile is in use; again, no diagnosis of mesothelial tumours is reported.

Dr. Gilson, Research Director of the M.R.C. Pneumoconiosis Research Unit, and his colleague, Dr. Wagner, have both stated in a number of papers that their major task at present is to "establish whether only one type of asbestos is responsible for the development of these tumours, and if other varieties can be exonerated".

4.4.3. Experimental Work: Wagner at the Pneumoconiosis Research Unit has shown (1964) that under animal experimental conditions, asbestos appears to be a powerful carcinogen. Twenty mg. of asbestos injected into the pleura of specific pathogen-free strains of rats has produced mesothelial tumours in a high proportion of animals. This is so for Chrysotile, Amosite and Crocidolite, both natural and after extraction of its natural oil by a single solvent. The investigation, a survival experiment, is not yet complete, thus, it is not yet known whether there are significant differences in the number of tumours produced by different types of fibres. So far, Amosite has produced the least.

Studies on the organic components of asbestos are being carried out by Harington of the Chester Beatty Research Institute. No hydrocarbons have been isolated from Chrysotile, but Crocidolite, which was mined in an area of South Africa with a high incidence of mesothelioma, contained 3,4 benzopyrene in relatively high amounts. Harington (1965) has also shown that during a storage period of 6 months, asbestos absorbs 70-85% of the jute oil present in jute sacks. It is not yet clear whether these oils are of any biological or medical importance.

The suggestion has been made that asbestos carcinogenicity may be related to the metals or metal complexes contained in asbestos fibres; Chrysotile contains nickel (0.5%) and chromium (0.1%), while Amosite has manganese (0.7%). Serum can elute small amounts of nickel, chromium, magnesium and manganese from Chrysotile, iron and manganese from Crocidolite and Amosite. Wagner's animal experiments tend to make the significance of iron unlikely, as the proportion of this element in Chrysotile is only about one tenth of that of Crocidolite or Amosite.

4.5 Aerodynamic Behaviour of Asbestos Fibres

4.5.1. Influence of Fibre Dimensions: Dr. V. Timbrell of the Pneumoconiosis Research Unit has been engaged for the past few years in examining the size parameters of fibres which influence their respirability. His investigations have explained the observation which puzzled earlier workers in this field, namely, the presence of fibres of 100 microns or longer in the lungs of men or experimentally exposed animals.

The explanation is that the particle-free falling speed is the most important parameter influencing its entry into the lung. This falling speed is predominantly determined by fibre diameter, and shows very little sensitivity to length, especially when the aspect ratio (length:diameter) is high. If, therefore, a fibre has a sufficiently small diameter, the falling speed can be low enough for the fibre to escape deposition by settlement and inertial precipitation mechanisms in the upper part of the respiratory tract. Hence, deep penetration to the pulmonary air spaces is possible. This has been shown to occur if the fibre diameter is less than about 3.5 microns.

4.5.2. Influence of Aspect Ratio: It would seem that the longer the fibre, the more probability there is of it being intercepted by the nasal hairs. However, examination of asbestos particle lengths in the lung has shown them to be of the same order of magnitude as the distances between the nasal hairs. The possibility thus arises that the fibres in airways, in which the airflow is laminar, may align themselves with the streamlines. Hence if the fibres are fine enough, they can be expected to show a capacity for wending their way through fine airways.

There is no direct evidence available on whether fibres do tend to align themselves with the air streamlines. Dr. Timbrell has assumed that the conditions in an aerosol spectrometer prevail in the lung airway. Consequently, he has measured the orientations of fibres in the particle deposits in this instrument. Figure 2 shows histograms in which percentage of fibres is plotted against angle to airstream in the aerosol spectrometer for glass, Amosite and Crocidolite fibres with aspect ratios <5. A similar histogram for fibres with an aspect ratio >5 is plotted in Figure 3.

It is seen from Figure 2, when the aspect ratios are < 5, there is no preferred orientation for any of the four fibres. However, for fibres with aspect ratio > 5 (see Figure 3) there is a definite tendency for the fibres of all four materials to align themselves with the direction of airflow.

Furthermore, it appears from Figure 3 that there is a more marked tendency for alignment of the glass fibres than for the fibres of the three types of asbestos. It is suggested that this is due to the highly symmetrical character of these synthetic fibres, whereas the asbestos fibres, although highly selected groups, exhibit slight asymmetry.

4.6 Standard Samples

At the International Conference on the Biological Effects of Asbestos in November 1964, one of the conclusions was as follows:

> "There are large differences both in morbidity and mortality of asbestos in the surveys in different parts of the world. These discrepancies may be explained by the different chemical nature of the minerals, but there is at the same time an urgent need to standardise radiological findings and histology."

The U.I.C.C. working party on asbestos and cancer also realised this problem, and suggested that international samples of the four main commercial types of asbestos be made available.

Dr. Timbrell supervised the production of such samples in Johannesburg at the end of July, 1966. The five samples produced were: Amosite (S.Africa), Crocidolite (S.Africa), Chrysotile (Rhodesia), Chrysotile (Canada) and Anthophyllite (Finland). The Canadian fibre consists of components from eight mines, and the most difficult problem experienced was mixing them so that any portion of the standard sample as small as a match head would be representative.

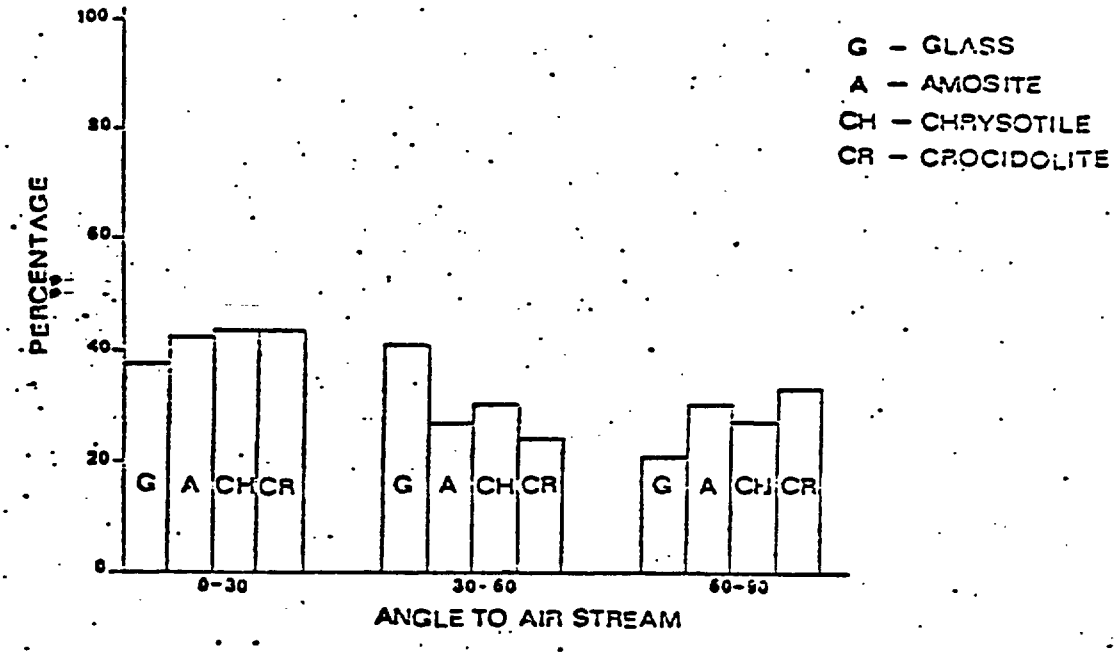


Figure 2: Frequency histograms in which percentage of fibres is plotted against angle to the airstream (axis of duct) in the aerosol spectrometer, for glass, amosite, chrysotile and crocidolite fibres with aspect ratios <5.

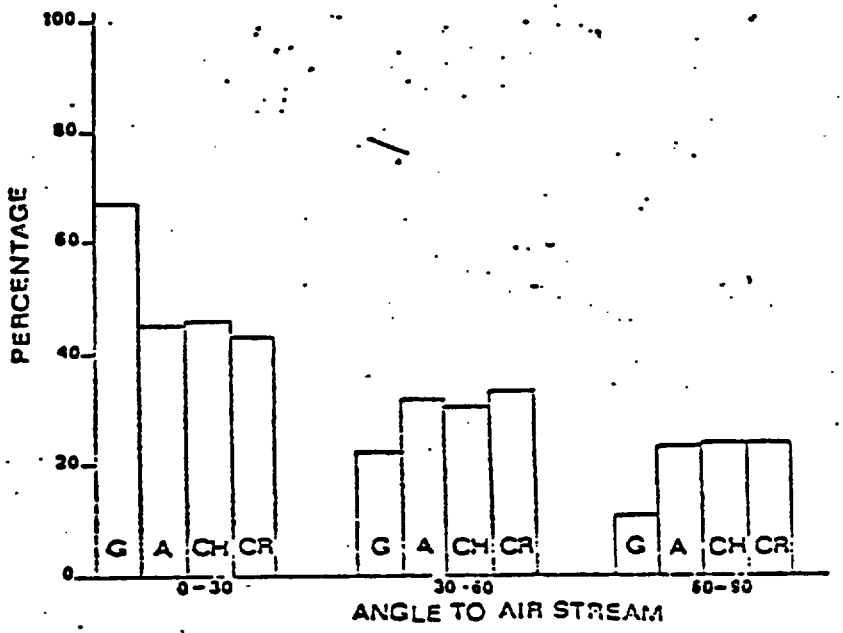


Figure 3: Frequency histograms in which percentage of fibres is plotted against angle to the airstream (axis of duct) in the aerosol spectrometer, for glass, amosite, chrysotile and crocidolite fibres with aspect ratios >5.

...been packaged into small samples, whic...
...properties of the samples are being made at a number of
research centres.

5.0 REQUEST FOR ANALYTICAL ASSISTANCE

It is understood that all the major asbestos producers in the U.K. have their assistance in conducting research work on the International Sample Dr. Timbrell asked Union Carbide U.K. whether the Corporation would be p to assist in a similar manner. He requested that we should carry out tr analyses of the five samples. Apparently, they have no adequate facilit Llandough Hospital for doing this. Dr. Timbrell has also requested that should examine identical aliquots of the Canadian Chrysotile sample to det whether uniform mixing was achieved in Johannesburg.

It was explained to Dr. Timbrell that it was impossible to give an immediat answer to his requests. He was, however, promised a reply at the conferenc the physics and chemistry of asbestos minerals to be held in Oxford on July Dr. Timbrell, and, hopefully, Drs. Gilson and Wagner, are scheduled to be at symposium, and arrangements have already been made for them to meet Dr. T. J. and Mr. F. Mumpton of the Union Carbide Corporation.

6.0 DISCUSSION

6.1 Moral Issues

6.1.1. There seems little doubt that the toxic effects of our Coalinga product are still largely unknown. There is a general inference that Crocidolite is more liable to produce mesothelioma. Exoneration of Chrysotile has not been made, however. A discussion with Dr. W. Taylor of the Department of Social Medicine, Queens College, Dundee, two days ago, revealed that concern over asbestosis is still increasing, and that Chrysotile is definitely implicated along with the other types of asbestos.

It therefore seems that on the basis of present evidence, we are not entitled under any circumstances to state that our material is not a health hazard. What is more, if it is believed that a potential customer would use our material 'dangerously', and that he is unaware of the toxicity question, then it must surely be our duty to caution him and point out means whereby he can hold the asbestos air float concentration to a minimum.

6.1.2. There has been a general recognition that Union Carbide has shown a praiseworthy responsibility in offering a pelletised product. Undoubtedly, this has contributed considerably to the continuance of negotiations with a number of papermaking firms, where dust extraction equipment to deal with an open product is inadequate.

On the other hand, the Resin Grade (open) and High Purity open materials do not possess this benefit, and the moral question is

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brought to the fore because sales of both are foreseen in the near future. Carbide's responsibilities are somewhat lessened, however, as the customers will mostly be firms already experienced in the use of asbestos, and those who are always under the watchful eye of the Factory Inspector.

6.2 Expected Rise in Asbestos Diseases

In Figure 4, a diagram has been presented relating the history of the development of the asbestos industry and associated health hazards. It is seen that the world production has increased tremendously since the war. With the knowledge that mesothelial tumours can take up to 40 years to develop, it is expected that there will be a dramatic rise in the next two decades in the number of cases discovered. If this hypothesis is proved correct, then it is certain that asbestos will receive increasingly more adverse publicity. As a result, sales resistance to our product may be expected to strengthen. It is therefore imperative that we keep abreast of current research work and publications, in order that we may combat both informed and exaggerated criticisms.

6.3 Threshold Limit Value

It is understood that the maximum dust level of 5 million particles per cubic foot (still adhered to by the U.K. Factory Inspectorate) was proposed by an engineer in 1938 as an interim guide. This figure was an arbitrary choice, and had no experimental foundation.

Dr. Taylor in his report of the International Conference on the Biological Effects of Asbestos, 1964, says:

> "The M.A.C. (Maximum Allowable Concentration) of 5 million particles per cubic foot is not now acceptable. Industry should aim at 1 million particles, and accept this figure with reservations until our knowledge in this field is extended."

Dr. Taylor reiterated this again two days ago, but he did admit that practically 2 million particles per cubic foot might have to suffice for quite a while to come.

It thus appears that the sentence in Dr. Dernehl's Asbestos Toxicology Report:

> "It is now generally accepted that a man can work a 40-hour week for a lifetime without developing asbestosis, if the asbestos dust particle count is kept at or below 5 million particles per cubic foot of air."

is now no longer held to be true by a number of informed people. An indication of the present opinion on this matter held by Union Carbide's Toxicology department would be most welcome.

6.4 Similarities Between Different Chrysotiles

At the moment, there are signs that Chrysotile may be less responsible than Crocidolite for the development of mesothelial tumours. Should it be proven, either on statistical grounds or histochemically, that this indication is indeed correct, then we must be certain that our material conforms closely

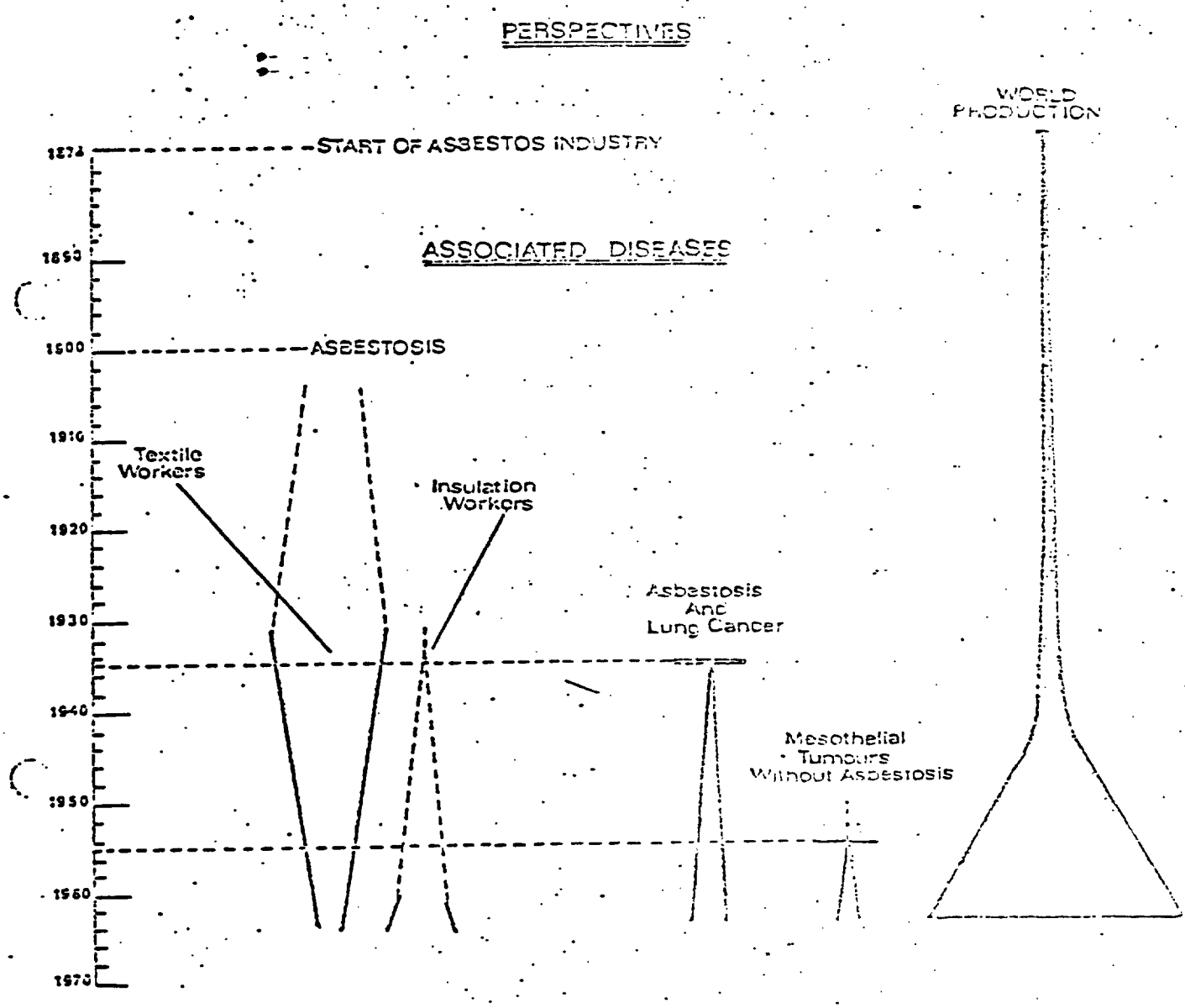


Figure 4: Diagram relating the history of the development of the asbestos industry and associated health hazards.

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to that variety of Chrysotile which has been vindicated. The case could arise, for example, that only one of the two Standard Chrysotile samples (Canadian and S.African) is given a total clearance.

6.5 Fibre Aerodynamics

One of the obvious differences between Chrysotile from the Coalinga deposit and that from other sources is its inherently small fibre dimensions. This, together with the unique wet refining method employed, has meant that there is a great abundance of very small liberated fibres available for inhalation into the lung.

The diameter of a single Coalinga fibre is less than 300 A^{o}. It has already been shown in 4.5.1. that fibres stand a good chance of deeply penetrating the lung if their diameters are about 3.5 microns or less. With a diameter at least 100 times smaller, there is no doubt that the Coalinga fibre is capable of reaching the innermost portions of the lung. This argument will apply to the fibre bundles contained in a bag of open material as well.

It may be seen from electron photomicrographs of Coalinga asbestos that the aspect ratio is usually much greater than 5, and that the fibrils are highly symmetrical, and are unassociated with gangue materials. Thus there is the likelihood that they will behave in a manner similar to fibreglass in Figure 3. As a result, they will have a greater tendency to align themselves with the direction of air flow. Assuming laminar flow in the bodily air passages, which in fact is probably not the case, the fibres will avoid contact with the nasal hairs, and so will be capable of passing into the depths of the lung.

7.0 RECOMMENDATIONS

7.1 Dust Counts

7.1.1. Bags: Dr. Dernehl in the Toxicology Report states:

> "In paper manufacturing, it would be desirable to know the dust concentrations where the asbestos is dumped from bags into the pulp slurry."

Dr. Taylor states recently that he believes there is more dust produced in opening a paper or plastic bag of asbestos than there is with a conventional hessian sack. He was questioned on his reason for this, but no satisfactory answer was forthcoming.

The author has himself witnessed a dust cloud in the vicinity of bags of both pelletised and open materials when making up customer sample bags after dark. A large number of suspended particles were visible in a torch beam.

It is recommended that a dust count be made in the region of a freshly opened bag of pelletised and open products. The readings obtained will be independent of the site of opening.

7.1.2. Cutters and Crêping Doctor: It is appreciated that dust conditions vary from mill to mill. A rough guide as to the amount of atmospheric dust present in the region of typical cutters and a crêping

doctor would nevertheless be very useful. The asbestos concentration would then be a small proportion of this. Dr. Taylor has suggested the use of the Royco instrument for a period of, say, 8 hours.

7.2 Analytical Assistance

It is recommended that Union Carbide offer to assist the Pneumoconiosis Research Council in trace element analysis of the Standard samples, for three reasons:

7.2.1. This unit is held in high esteem in the U.K. Carbide's aid would enable us to maintain close contact with the unit, and so enable us to keep up to date with current research work and ideas. Drs. Gilson, Wagner and Timbrell are leaders in the field in Great Britain. It was noticeable too that "at the New York Academy of Sciences Symposium on the Biological Effects of Asbestos held last Autumn, about half the contributions were from the U.K."

7.2.2. Dr. Timbrell has shown great interest in our material, mainly because of the symmetry and uniformity of the fibre structure. He has stated his intention of doing some animal inhalation experiments with it. We therefore stand a good chance of having the Coalinga material, at least in part, evaluated alongside the Standard samples.

7.2.3. The fact that we would be assisting research would make a good selling point. It is felt that if customers see that the company has recognised a problem, has tried to define it, and is subsequently offering assistance towards a solution, then they cannot refuse to buy solely on toxicological grounds.

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Published by AsbestosClaims.Law
asbestosclaims.law/library/16516/19