PLAINTIFF'S EXHIBIT ASA-124 4

Ann. Occup. Hyg. Vol. 11, pp. 135–145. Pergamon Press 1968. Printed in Great Britain

ASBESTOS HAZARDS IN NAVAL DOCKYARDS*

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Abstract—A brief description is given of the types of asbestos materials, and their uses in shipbuilding and ship repairing in Naval Dockyards. An outline of the problems to be faced and a description of preventive methods is followed by a series of questions intended to stimulate practical solutions to the problems of using asbestos materials safely in the industry.

SO MUCH has been written and spoken about asbestos in the last five years that it might seem irrelevant to add any more to the vast mountain of words, facts and figures already expounded.

I know that there is a keen awareness in Newcastle of the problems associated with asbestos in the shipbuilding industry and that a great deal of work has been, and is being done, by the Department of Occupational Medicine to further knowledge of the disease and to suggest a suitable code of practice for the use of asbestos in the industry.

With this knowledge in mind it was with great trepidation that I approached the preparation of this paper. After some thought I came to the conclusion that it would not be very much good trying to tell you anything, but that here was a wonderful opportunity to see if you could answer some of the questions that we face in the Royal Navy as we search for the current solutions to the problems associated with the use of asbestos in building, repairing and refitting ships.

I have come to Newcastle hoping to learn, and I hope to put specific questions to you, the answers to which we must know if we are to deal effectively with the problems of using asbestos safely.

I think it fair to begin by outlining the problems as I see them, to describe what the Navy is doing about them, and then to ask for your solutions to them.

THE INDUSTRY

There are four Royal Dockyards in this country, at Portsmouth, Devonport, Chatham and Rosyth, and a small amount of refitting work is done in Singapore and Gibraltar. These remarks are confined to the four home dockyards who between them employ some 50,000 civilians. About 17,000 men work afloat on the ships while the remainder work in the shops, factories and docksides. Less than 450 men are classed as asbestos workers and only the 50 men who work in the asbestos mattress shops are subject to the Asbestos Industry Regulations.

*This paper was originally presented at the 22nd Conference of the British Occupational Hygiene Society, Newcastle upon Tyne, September, 1967.

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Most of the work carried out in the Royal Yards is refitting and repairing ships, rather than shipbuilding which accounts for most of the work undertaken in the civilian yards. The extent of the refits also differs in that naval refits are usually much more extensive and often involve the removal and replacement of nearly all the insulating material in machinery spaces. As the removal of lagging material gives rise to more dust than its application these are very important differences.

For these reasons, and for the many engineering and constructional differences between naval and merchant ships, I believe that the overall exposure to asbestos is likely to be higher in the Naval dockyards than in their civilian counterparts.

Materials

The asbestos materials used in Naval ships are largely the same as those used in the Merchant Fleet. Changes have occurred in the amounts and types of material used which I think may help to explain the emergence of asbestosis in the dockyards as a problem at this time.

From the start of this century to about 1950 most of the machinery insulation was in the form of asbestos mattresses, 85 per cent magnesia sections containing 15 per cent amosite, and asbestos cloth. A certain amount of crocidolite was used in fibre form for mattresses, and in some asbestos board.

From 1950 onwards more efficient insulation was required and magnesia sections were replaced by massive amosite sections consisting almost entirely of asbestos. The dwindling stock of amosite sectional lagging is still being used in small amounts but calcium silicate section containing only 12–15 per cent amosite has been increasingly used since 1963.

The use of large amounts of amosite section from 1950 onwards has meant that there has been a great increase in the amount of asbestos exposure over the last seventeen years.

The sprayed asbestos process was used extensively in naval ships from the end of the war until 1963 when it was discontinued, largely for reasons of weight. Nearly all the fibre used in this process was blue, but amosite fibre was sometimes used.

There are very many other uses of asbestos containing materials in ships and it is difficult to find a compartment in which there is no asbestos. Table 1 indicates most of the asbestos materials used in the dockyards, and they have been sub-divided into those giving rise to dust in their manipulation and those not usually giving rise to dust unless they are ground, polished or sawn. It will be realised that most of the asbestos is used for heat insulation although extensive use has also been made of asbestos sound and electrical insulating materials.

Processes

Mattress making. In each dockyard this is carried out in shops equipped with exhaust ventilation cowls in which the mattresses are filled with amosite fibre. Working conditions are good and dust concentrations are low. Some crocidolite has occasionally been used in the past and the men preferred it to amosite as it was less dusty and less spiky than amosite. WYERS (1946) has previously commented on the workers dislike of amosite asbestos.

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TABLE 1. ASBESTOS MATERIALS USED IN NAVAL DOCKYARDS

Dusty		Non dusty	
Asbestos:	Blankets	Asbestos:	Cloth (treated)
	Cement		Condenser packing
	Cloth (untreated)		Sheets (compressed fibre)
	Cord		Gaskets
	Fibre		Oilproof jointing
	Millboard		Compressed fibre jointing
	Packing fibre		Graphited packing
	Rope		Rings
	Soft sound insulation		Compressed sound insulation
			Jointing strips
			Tape
			Tubing
			Twine
			Webbing
			Washers
			Coated electric wire

Calcium silicate sectional lagging (up to 15 per cent asbestos)
Amosite sectional lagging (over 90 per cent asbestos)
Magnesia compound (up to 15 per cent asbestos)

Lagging. The application and removal of heat insulating materials is mainly concentrated in the machinery spaces aboard ships and present practice is to lag all hot faces above 150°F with calcium silicate sections covered with asbestos cloth. Cutting and fixing sections, rope and cloth does give rise to localized high dust concentrations, but the highest dust concentrations occur during removal of old lagging material.

Hot and cold water pipes and ventilation trunking throughout the ships have previously been covered with asbestos cloth, but this is now replaced by cork, felt and canvas.

Asbestos spraying. This process was extensively used for environmental insulation until 1963 when it was completely discontinued. The existing material is extensively removed during refits and is being replaced by glass fibre. The dust concentrations during removing the dry material are very high.

Application of sound insulation. Asbestos boards of various types and thicknesses have been sawn and fitted for sound insulation and removed during subsequent refits. This work is done by joiners, and again the highest dust concentrations occur during removal of the old material.

There are many other minor processes involving the fitting or removal of asbestos materials some of which do produce dust. Examples are the fitting and removal of asbestos in galley equipment; sawing and fitting friable asbestos board for ironing boards, cleaning with wire brushes, pipes and glands previously lagged with asbestos. Most of these procedures are carried out intermittently by men who are not considered to be "asbestos workers".

The men

First impressions of the problem would suggest that only those men continuously working with asbestos are at risk. In the dockyards these men would be the mattress

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workers, laggers, sailmakers working with asbestos cloth, asbestos sprayers and strippers, and storeman. Experience has shown, and further consideration of the industry and processes should suggest, that many other men have been at risk.

As most of the asbestos has been applied and removed in machinery spaces it is amongst men working mainly in these compartments that we might expect to find evidence of the disease. Table 2 shows the occupations of men in Devonport Dockyard who are NOT recognised asbestos workers, and who have been accepted by the

TABLE 2. OCCUPATIONS OF MEN WITH ASBESTOSIS* (DEVONPORT DOCKYARD)

Boilermaker
Electrical fitter
Engine fitter
Engineer
Iron caulker
Joiner
Plumber
Rivetter
Shipwright
Shotblaster
Stoker
Welder

*Other than asbestos workers.

Pneumoconiosis Panel as suffering from Asbestosis in the last year. All these, with the exception of the joiner and shot blaster, work on ships mainly in machinery spaces. The joiner cuts, fits and tears down Acoustic insulation periodically. The shot blaster spent years cleaning and blasting asbestos coated pipes.

Table 3 shows the occupations of men histologically proven to have been suffering from pleural mesothelioma in Devonport Dockyard. It will be seen that none of these is a recognised asbestos worker but that they have all had considerable asbestos exposure on ships under refit.

TABLE 3. OCCUPATIONS OF MEN WITH PLEURAL MESOTHELIOMA (DEVONPORT DOCKYARD)

Boilermaker
Fitter
Labourer on ships
Shipwright
Welder

The diseases

We are concerned with three disease processes. Asbestosis; carcinoma of the lung associated with asbestosis or asbestos exposure; and pleural or peritoneal mesothelioma associated with asbestos exposure. All three conditions take a long time to cause symptoms and have insidious onsets, and this makes it more difficult

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to enforce preventive measures, as the need for them is often not realised. All three disease processes are occurring in Devonport Dockyard and there is no reason to believe that the situation is very different in the other Royal Dockyards.

Dust

Asbestos dust is liberated during manipulation, and especially during vigorous tearing down of most of the asbestos materials used in the dockyard. The main problem is to contain the dust and prevent dispersal throughout the ship. In machinery spaces the asbestos insulation is applied to a maze of pipes and machinery much of which lies in awkward and inaccessible positions. For these reasons efficient exhaust ventilation at the source of dust emission is difficult, and, as the work is progressive the exhaust system has to be portable. The question of discharge of the exhaust also poses problems as often the machinery spaces are many decks below an exit to the open air.

The long and difficult access to machinery spaces is one reason against wetting the insulation prior to or during its removal. Trials of infusing the lagging with probes, and spraying with low pressure water spray during removal showed that not only did these methods very considerably slow the progress of the work, but they made the asbestos debris three times as heavy when wet as when in the dry state. As it all has to be manhandled out of the ship, weight is a very important factor.

As the dust arising from most of the materials used is mixed dust I am employing both gravimetric and fibre counting methods to give an idea of the amount of dust and the content of fibre. Dr. V. Timbrell of the P.R.U., Penarth, has kindly provided me with M.R.E. gravimetric samplers which I use in pairs, one being adapted to sample "total" dust, the other "respirable" dust. Fibre counts are carried out using methods recommended by the Asbestosis Research Council (HOLMES, 1965).

Table 4 shows the range of fibre counts in various occupations but I must emphasize that these results are examples only and it will be some time yet before I

TABLE 4. RANGES OF DUST CONCENTRATIONS

Process	Range (fibres/cm³)		
Storerooms	0·1	—	36
Application of amosite sections	9	—	40
Application and stitching asbestos cloth	0·05	—	0·26
Removal of amosite sections (boiler room)	29	—	1040
Removal of blue sprayed asbestos	112	—	1906
Removal of asbestos acoustic board	48	—	683
Bagging asbestos debris	106	—	3815

Membrane Filter samples taken by Drager hand pump, Austen Dymax Pump or Hunt Personal sampler. Technique of evaluation as described by Asbestosis Research Council 1964 (HOLMES, 1965).

have enough data to give a more detailed picture of the situation. I think it is obvious enough that it is in the removal, or tearing down of asbestos materials that the greatest dust concentrations are to be found, but we need a lot more sampling experience before we can build up an accurate picture of the exposures during application of lagging.

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THE PROBLEMS AND CURRENT ACTION IN H.M. DOCKYARDS

I have attempted to show that as an industry the Navy uses large amounts of many different products containing asbestos in varied and difficult working conditions. The work often gives rise to high dust concentrations and many people working near the different processes may be exposed to the hazard. We know that men other than those working directly with asbestos are contracting asbestosis.

At present the uses of all asbestos containing materials are being studied with a view to using alternative materials, and crocidolite is being excluded from ships. Where substitution is not possible and asbestos materials are used, or existing asbestos materials are removed, the following precautions are taken.

As far as possible the work is isolated and only those actually involved in the process of lagging or stripping are allowed into the compartment. Where possible, supply and exhaust ventilation through a filter is provided but satisfactory ventilation systems are most difficult to arrange.

As dust suppression is not possible we have to rely almost entirely on personal protection. Where large amounts of machinery lagging, sound insulation, and particularly sprayed asbestos is to be removed then the men wear impervious overalls made either of P.V.C. or rubber, and an air line P.V.C. hood supplying fresh air via the dockyard compressed air lines. Despite the difficulties of the work, and the discomfort of the overalls, the men have removed over 500,000 ft² of sprayed crocidolite asbestos from H.M.S. *Ark Royal* using this form of protection. At present we also have on trial Positive Pressure Powered respirators manufactured by Martindale Electric Co. Ltd., which are proving very popular with the men. They have the advantage of supplying adequate filtered air making them very comfortable to wear, and do not have the disadvantage of the trailing air hoses which are difficult to untangle in the confines of a boiler room.

For the application of lagging or sound insulation materials, and in the stores when moving or cleaning asbestos, Siebe Gorman Mark VIII dust respirators are worn together with Bri-nylon overalls. Experiments are planned to lag the pipes in the shop and fit them ready lagged.

The asbestos debris is bagged in paper sacks, sealed and carried off the ship after the end of normal working hours. The bag is then pierced with a probe, filled with water, and placed in a barge from which it is eventually dumped at sea. The ship's compartments are cleaned with industrial vacuum cleaners by men wearing full protective clothing.

All the men who are expected to work most of their time with asbestos have initial and annual medical examinations and chest X-ray at the dockyard medical centres, and this has been the procedure from the beginning of lagging in the dockyard.

What we are doing is to limit the amount of asbestos used, to limit the number of men exposed to the dust and as far as possible to protect those who have to be exposed to the dust.

All this is expensive. Refit schedules are now planned to exclude other trades from compartments in which removal of lagging or sprayed asbestos is proceeding. The use of uncomfortable and sometimes cumbersome overalls and air hoods has slightly slowed down the rate of work. It is to the credit of both the management and

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men that these measures have been proved to be possible, but I think that it is highly desirable that we should attempt to more clearly define the risks, so that we can employ more appropriate preventive methods.

A Medical Research Unit working closely with the Pneumoconiosis Research Unit at Penarth has been set up in Devonport Dockyard to attempt to define some of the risks more clearly. Work is proceeding on a detailed study of 420 men with varying asbestos exposure. Mortality studies of asbestos workers and other dockyard employees is under way, and a dust sampling programme is being carried out to give some idea of the dust exposure of most of the procedures producing asbestos dust in the dockyards.

Questions to be answered

Asbestos is a very useful material and for some purposes it is irreplaceable in the shipbuilding industry, but in order that we can continue to use it safely we must know the answers to many questions. The solution to these problems will only be found after close co-operation between marine engineers and constructors, physicians, industrial hygienists, the Asbestos industry, management and men.

Engineers and constructors must be asked why asbestos is specified in their ships, and whether or not an alternative material would perform as well, more safely and as cheaply.

Management must be asked to plan the work of building or refitting a ship so that the minimum number of men is exposed to asbestos.

Men must be asked to treat with respect a material which can be dangerous when handled carelessly.

Physicians probably have to answer more difficult questions.

1. What exposure in terms of dust concentration and duration is required to set in motion the disease process manifesting itself as asbestosis? Is it still necessary to envisage long continuous exposure before we think that pulmonary fibrosis may be due to asbestosis, or is a short exposure sufficient given enough time for the disease to develop? The latter has already been suggested by McVittie (1965) and Gold and Cuthbert (1966). Is this an argument against the suggestion that laggers should only be employed as such for limited period of time?

2. What are the criteria for making an early diagnosis of asbestosis? If we are to achieve anything useful from periodical medical examinations then surely at the first indication of impending asbestosis exposure to asbestos should cease? Hunt (1965) has suggested that men removed from further exposure to asbestos as the result of finding early impairment of lung function at routine examination have not shown further deterioration.

At present to advise a lagger to seek alternative employment because he shows early signs of impaired lung function, and before he is considered compensatable by the Pneumoconiosis Panel means a serious financial loss for the man. This is a very real dilemma. If we wait until the diagnosis is certain the disease may progress fairly rapidly and soon become "compensatable". If on the other hand he is removed from exposure at an early stage he may not show further deterioration, or may do so at such a slow rate that we may never be certain of the accuracy of the diagnosis.

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Surely this must be our aim, to reduce to the minimum the number of cases of proven, compensatable asbestosis. Enlightened management and unions must seek ways to retrain and re-employ these men without financial loss and at no further risk to their health.

3. Is it safe to use crocidolite in any amount where air borne dust is produced? The experiences in our dockyards over the next two decades may partly help to answer this question.

Occupational hygienists together with physicists and ventilation engineers will have to help in answering these questions and the further problems arising from them.

1. We want to know the most suitable method for sampling asbestos dust?
2. What standards are we to aim at in dust control?
3. What are the best methods of dust control for our industry?

We want to know what dust levels are produced by the different processes and what protective measures must be taken by the men doing the work. Is it justifiable to allow other men to work without respiratory protection in a boiler room where lagging is being applied? How long after lagging or stripping has finished do we have to wait before it is safe for other work to proceed without respiratory protection? Are there suitable, effective, portable dust extraction units for use in ships?

The Asbestos Industry is undertaking intensive research into most of these problems. Can the industry produce insulating material which does not emit asbestos dust?

I have told you what we are doing to face up to the problems as we see them in the light of present knowledge, and I have put to you some of the questions we want answered. Can you help us?

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DISCUSSION

Dr. HICKISH said that the Society had a Standards Committee dealing with asbestos, and it was hoped that a comprehensive standard would be produced later this year.

Dr. GAZE (The Asbestosis Research Council and The Cape Asbestos Company) said that the asbestos industry was anxious that its products should be used safely and that the true facts concerning the hazards should be brought to light. For that reason they very much welcomed the author's clear and objective account of his investigation, and this opportunity to discuss it.

The conditions that the author had described had clearly been unsatisfactory in the past; as far as he could judge, they corresponded approximately to the conditions which prevailed in the factories in the asbestos industry 30–40 years ago. It was at that time that it was first realised that there were hazards associated with the inhalation of asbestos dust. It was reassuring to know that, apart from the precautions which had been mentioned, things would be vastly better in the future, because asbestos spray was no longer used in Her Majesty's ships, and the types of insulating material that were now used for lagging in engine rooms contained very much less asbestos than the materials that were used ten years ago. It was true that there would continue to be a problem in the stripping of lagging, but this would diminish as new materials came into use.

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The author had challenged them by asking some extremely pertinent questions about the health hazards that existed with asbestos and what could be done about them. There were about thirteen key questions and the asbestos industry, from its own experience, was in a position to attempt to answer many of them. Dr. Gaze said that time did not allow him to discuss them all at length, but he would comment on some.

The first set of questions dealt with the relationship of exposure to dust and the onset of asbestosis. The obtaining of an answer had been bedevilled by the difficulty that the onset of asbestosis was so slow. However, the industry was in a good position to try and help because in many factories there were now records of dust concentrations over a long period, and the medical records in most asbestos factories were very complete. A pattern was now emerging as a result of which it was becoming possible to relate the onset of asbestosis with time and concentration of asbestos dust.

The next series of questions concerned early diagnosis. He did not pretend to be an expert on the medical aspects, but it appeared to him that they were now in a position to diagnose asbestosis very much earlier than was possible five years ago. The techniques for diagnosis were now reasonably clearly established, although many of them were still somewhat subjective. However, in the view of the asbestos industry, the earlier that diagnosis could be obtained, the better. Much hinged on how the word "early" was interpreted; there was always a point at which one had to speculate. The consensus of opinion was that it was better to remove workers who were suspect at as early a stage as possible from exposure to asbestos, although this was a clinical answer and it was appreciated that there were human difficulties which could occur.

The next question concerned crocidolite, blue asbestos. It was suspected that blue asbestos was the form of asbestos principally associated with mesothelioma. The asbestos industry in this country had decided that it would exercise a voluntary control on the importation and use of crocidolite asbestos, with the object of confining it to those applications where its unique properties made it essential and irreplaceable. As far as he was aware, there was now no reason why blue asbestos should be used at any point in Her Majesty's ships or in any shipyard.

The final question was whether the industry could produce an insulation that would not emit asbestos dust. It was difficult to give an answer, yes or no, without considerable qualification. Perhaps the best way of answering would be to say that the industry was working hard in order to achieve precisely that end. In recent years, forms of insulation containing very much less asbestos than hitherto had been successfully manufactured and used. Asbestos continued to be essential in certain applications, particularly in the control of spread of fire at sea. This was one of the most crucial applications of asbestos products; in order fully to comply with the requirements of the International Regulations concerned with the prevention of fire at sea, the use of asbestos continued to be essential. For such purposes asbestos would continue to be essential, and it was equally essential that industry should find the safest way of manufacturing and using it.

Dr. MURRAY said that the position in the trade unions varied. There were some people who were so afraid of asbestos that they wanted the material banned altogether, while there were others, within the industry particularly, who appeared to handle it with impunity. The trade unions were now learning something about the technical aspects of the use of asbestos and they did not see why it should be used where alternatives were possible. He was glad to see that the author was using this approach in the naval dockyards. He agreed that there were certain applications in which asbestos was essential. The position in regard to crocidolite was particularly worrying, and he was glad to hear that Dr. Gaze thought that it was not necessary to use crocidolite asbestos in any of Her Majesty's ships. But there was the question whether the technical properties of crocidolite asbestos were such that in any circumstances at all it was necessary to use it.

The trade unions appreciated that there were certain circumstances in which protection had to be used. He was grateful to Mr. Sanderson for doing some work on a building site in Glasgow in which he was able to demonstrate to the satisfaction of the building workers, after a strike, that by the use of certain methods it was possible to control the asbestos in the atmosphere to a reasonable level. The wearing of protective clothing had to be regarded in this light. Nobody liked wearing protective clothing, but if people had explained to them the reasons why certain types of protective clothing were necessary under certain circumstances, then they would wear it with intelligence and co-operation. The problem of the use of asbestos would remain for a long time.

Dr. FLETCHER said that nobody who had ever been in the engine room in the last two months before a ship went to sea could regard the issue as being one of, "How are we going to comply with the regulations?" as long as asbestos was in use. Pipes were put in willy-nilly, without planning. The first man there got his pipe in. Pre-formed insulation for engine room pipes was non-existent. The answer seemed to be to use only a selected number of workers to do the work, and then to close the

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engine room space when it was done, vacuum cleaning the space twice a day. Care had to be taken to see what happened to the air.

As regards mesothelioma, there seemed to be some doubt as to what caused it. He was not happy that the present respirators were sufficient protection. Management had no idea what to do about it. The use of respirators would add thousands of pounds to the construction of an engine room, and there would also be delay.

As a substitute for asbestos, there was a fibre from sugar cane. Once that could be economically produced, it would be an answer for the bulkhead ceilings.

Dr. GLOVER said that on the one hand there was asbestosis which fibrosed the lungs; this had been known for many years, and occurred in asbestos workers. On the other hand, mesothelioma seemed to occur in those who had no direct contact, such as the woman who washed factory overalls, but appeared to be rare among asbestos workers. Was there some mutual exclusion? Was a person who got asbestosis less likely to get mesothelioma?

He thought there was no case at all for using crocidolite in lagging. This blue, straight, brittle fibre asbestos is not very suitable for weaving and could, perhaps, be banned entirely.

Dr. SMITHER (Cape Asbestos Co.) said that it was not true that there were more cases of mesothelioma occurring outside asbestos workers than inside. Unhappily, cases of mesothelioma were still arising. It was hoped that in the future those cases would be fewer, because no blue asbestos was now being used by his company; blue asbestos was not now being used in cloth.

Every time that mesothelioma was mentioned, the unfortunate woman who washed overalls was quoted. She had three daughters who worked for the Cape Asbestos Company; they would not accept the service offered by the company but took their overalls home for mother to wash. When one held up an overall and dusted it, a much greater cloud of asbestos was produced than any worker produced anywhere in the industry. Such people, far from getting minimum exposures, were getting maximum exposures, much higher than the average worker got at any one time. Miss Newhouse now accepted that this exposure was heavy; she said : "In most of the patients, exposure occurred before the introduction of controls into the industry, and even with short periods of employment, exposure may have been very heavy." Past conditions and their results should not be extrapolated to future predictions without real justification.

Dr. D. L. CRAN (Pneumoconiosis Medical Panel) replied to Dr. Glover that mesothelioma did occur in cases of asbestosis, so they were not mutually exclusive. However, it was true that the vast majority of cases of mesothelioma which he saw were not cases of asbestosis. The main difference appeared to be that asbestosis required long periods of exposure, while mesothelioma could occur long after a short intensive exposure. Continued exposure could produce mesothelioma and at the same time produce asbestosis.

Dr. S. HOLMES (Asbestosis Research Council) said, in reply to Dr. Glover's statement, that very little blue fibre was used in asbestos textiles. The main use in textiles used to be in the making of railway engine mattresses, and that trade had almost gone with the introduction of diesel and electric engines. Protective clothing was now made from white asbestos.

Dr. C. N. DAVIES commented on the simultaneous occurrence of asbestosis and mesothelioma. The chemical analysis of particles and fibres might be the same, but the association of asbestosis with particles was rather devious. Recent work suggested that mesothelioma was associated with the leeching out of metallic constituents, and this could occur from particles or fibres, possibly irrespective of the place of deposition in the lung. One had to consider whether for asbestosis fibres were necessary, whereas in mesothelioma particles might be just as effective as fibres.

Dr. CRAN said that he had recently had a case of a man with mesothelioma completely confined to the abdomen and not to the chest. How a man could get that when he breathed in asbestos fibres, nobody knew.

Dr. SMITHER said that it was difficult to see the role of fibres in the peritoneum. His own experience was that peritoneal mesothelioma was as common as pleural mesothelioma, and he had heard recently that in America they were now finding a very much higher proportion of peritoneal mesothelioma than was expected. He pointed out that the fibres went into the nose and throat; some went into the mouth and were spat out; some were trapped in the nose. A great many of the fibres that went into the trachea were swallowed. He had no difficulty in imagining the route by which the fibres got down. One could talk about amorphous asbestos, but under the electron microscope,

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asbestos was not amorphous, it was nearly all fibrous; it was intra-cellular. It had been shown that the phagocyte would ingest asbestos; pictures existed showing bits of asbestos held within the phagosome, and the leucocyte giving up asbestos. The old idea of a mechanical irritation, with a fibre tickling away at the lung, was not believed nowadays. It was known that this was an intra-cellular biochemical process, and it could occur with small particles; it could also occur with long particles. When the longer particle was in the gut, there seemed to be a delay period before that particle broke up. It was ingested by the phagocyte upon which it acted biochemically and caused the phagocyte to turn into a fibroblast and produce extra-cellular fibrous tissue.

Dr. DAVIES said that one had to go back a stage further in the process, and say how the fibre got there. He drew the comparison with silicosis. In asbestosis of the lungs was little mobility; hence there was far more dissemination in the general picture than with silicosis where focalisation of particles took place because silica particles were moved by phagocytes.

As regard peritoneal mesothelioma, might this not be due to fibres which had been swallowed and then penetrated the gut?

Written contribution by Dr. R. Gaze

(Asbestosis Research Council and The Cape Asbestos Company Limited)

It is repeatedly alleged that quite small and possibly brief exposure to asbestos dust may cause asbestosis or mesothelioma many years later. Although the evidence in regard to crocidolite is still rather conflicting, there is a great deal of evidence from medically supervised long service employees in chrysotile and amosite mines, and in factories using these fibres, that lengthy exposures to low or moderate amounts of dust (say less than 5 fibres/c^3) or exposures to large amounts of dust over short periods do not cause injury or even detectable morbidity.

Many of us in the Industry have believed for a long time that most of the cases of diseases found by epidemiological surveys and thought to be due to minor exposure have in fact been caused by uncontrolled and severe exposures on occasions of which there may be no record, and Dr. Harries' enormous counts of air-borne fibres during stripping of old insulation add considerable support to this view.

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