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HM FACTORY INSPECTORATE

Problems arising from the use of Asbestos

MEMORANDUM of the Senior Medical Inspector's Advisory Panel

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Problems arising from the use of Asbestos

MEMORANDUM of the Senior Medical Inspector's Advisory Panel

LONDON: HER MAJESTY'S STATIONERY OFFICE
1967

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Membership of the Advisory Panel on Problems Arising from the Use of Asbestos

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Miss N. A. Davis	Ministry of Labour

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To the Right Hon. R. J. GUNTER, M.P. Minister of Labour

HM Factory Inspectorate

Conclusions of the Senior Medical Inspector's Advisory Panel on Problems arising from the use of Asbestos

SIR,

The health problems associated with occupational exposure to asbestos dust have long been of considerable concern to HM Factory Inspectorate. Awareness of these health risks has become much more widespread over the last two or three years and public interest was particularly stimulated by the publication in the October 1965 issue of the British Journal of Industrial Medicine of an article by Dr. Newhouse and Dr. Thomson about the association between exposure to asbestos and mesothelioma of the pleura and peritoneum.

HM Medical Inspectors of Factories have considerable knowledge and expertise in the field of industrial medicine which they supplement in dealing with particular problems of complexity by seeking information and advice from workers specialising in the particular topic. In the case of health hazards arising from the industrial uses of asbestos, the Senior Medical Inspector felt that this advice could best be obtained by convening a Panel of recognised experts to meet and discuss these problems. The Panel held its first meeting on 23rd July 1965. It is still in being and gives continuing information and advice to the Senior Medical Inspector, in the light of which he in turn formulates the advice which he gives to this Department.

In the first eighteen months of its existence the Panel considered a number of questions put to it by the Senior Medical Inspector and formulated its conclusions on them. It has seemed to the Senior Medical Inspector and to me that these are of much wider interest and that it would be appropriate to give them wider publicity than they might otherwise receive. These conclusions should perhaps be regarded as evidence put to the Department by a group of persons who are each recognised experts in their own field. The Panel make a number of suggestions for future action which will have to be considered within this Ministry and perhaps in conjunction with other Government Departments. They may well have to be considered in the light of factors which it would not have been appropriate for the Panel to take into account.

In view of this I have naturally considered whether it would be appropriate to publish the memorandum as it stands. I have, however, reached the conclusion that it would be right to do so. It collects together a great deal of information for the first time. Some new information has been added, but its main value perhaps lies in the consideration of known facts which have hitherto not been collated. It represents the considered opinions of a number of leading experts on the association between exposure to asbestos dust and disease, and it makes, I think, a noteworthy contribution to our knowledge and understanding of this subject.

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Finally, I should like to express my gratitude both to the Senior Medical Inspector and to the members of the Panel for the work they have done. Their conclusions have been formulated as the result of a great deal of hard work and painstaking study. I am especially grateful to the individual experts who have agreed to advise the Senior Medical Inspector in this way for giving so freely of their time, experience and knowledge to advance our understanding of a complex and important problem.

I am, Sir,

Your obedient Servant,

R. K. CHRISTY
HM Chief Inspector of Factories

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itude both to the Senior Medical or the work they have done. Their lt of a great deal of hard work and o the individual experts who have r in this way for giving so freely of ance our understanding of a com-

bedient Servant,

K. CHRISTY
HM Chief Inspector of Factories

Problems arising from the use of Asbestos

Introduction

1. Asbestosis, a fibrotic condition of the lungs occurring in those exposed to the mineral asbestos, was first clearly recognised as an entity and occupational disease in the late 1920s although attention had earlier been drawn to isolated examples.

The first suggestions that asbestosis might be complicated by the development of carcinoma of the lung followed within a few years but an association was not generally accepted until the 1950s. In recent years, there has been concern over the occurrence of mesothelial tumours of pleura or peritoneum which appear in many instances to be causally related to asbestos exposure. There is also evidence suggesting that these mesothelial tumours, at one time considered to be pathological rarities, are becoming commoner and that where asbestos exposure has occurred, that variety known as crocidolite or 'blue asbestos' is of particular significance.

2. The Advisory Panel on Problems arising from the Use of Asbestos was convened by HM Senior Medical Inspector of Factories to consider the use of asbestos in relation to the health of those directly or indirectly exposed in the course of their occupations and to make recommendations to the Senior Medical Inspector. The first meeting of the Panel was held on 23rd July 1965, and in all, the Panel has met on five occasions, completing this memorandum on 12th June 1967.

TABLE 1—*Imports of raw asbestos fibres into the United Kingdom*

Year	Amosite	Crocidolite	Chrysotile	Total	Board of Trade Total
1925	—	—	—	—	26,118
1930	—	—	—	—	25,117
1935	—	—	—	—	32,407
1939	—	—	—	—	60,404
1940	—	—	—	—	94,182
1945	—	—	—	—	68,178
1950	—	—	—	—	120,132
1954	12,398	7,923	102,924	123,245	—
1955	14,330	9,504	112,678	136,512	145,328
1956	16,711	4,220	118,515	139,446	—
1957	17,017	8,568	100,237	125,822	—
1958	19,274	7,503	96,160	122,937	—
1959	18,598	6,973	110,544	136,115	—
1960	27,028	7,088	143,197	177,313	168,326
1961	23,024	6,684	143,827	173,535	—
1962	21,125	6,126	122,444	149,695	—
1963	20,475	7,902	129,177	157,554	—
1965	—	—	—	—	176,082
1966	—	—	—	—	190,498

These figures are in part reproduced from a paper by Hinson[1] and expressed in short tons. The last column is based on information supplied by the Board of Trade and expressed in long tons. A striking feature is the constancy of imports of crocidolite into the United Kingdom over the last ten years, whereas world production has been rising steeply. Much of this new production goes to the USA and Europe.

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Asbestos: mineralogy, sources and consumption

Mineralogy

3. 'Asbestos' is the generic name applied to minerals having a fibrous cleavage. Two distinct groups are recognised:

(*a*) Fibrous serpentine: example—chrysotile (white asbestos). Chemically, chrysotile is a hydrated magnesium silicate. The finest fibres have a tubular structure.

(*b*) Amphibole asbestos: examples—crocidolite (blue asbestos) and amosite. Chemically, crocidolite is a sodium ferroso-ferric silicate: amosite a ferrous magnesium silicate. The finest fibres have a solid as distinct from a tubular structure.

Sources and consumption

4. About 85 per cent of the world's annual production of asbestos comes from Canada, the U.S.S.R., Southern Rhodesia (all chrysotile) and South Africa (chrysotile, amosite and crocidolite). The only other source of crocidolite of commercial significance is Western Australia.

TABLE 2

Breakdown to industry of United Kingdom Imports of asbestos—1964

	Amosite		Crocidolite		Chrysotile		Total	
	Tons	%	Tons	%	Tons	%	Tons	%
Fillers and reinforcement in such products as: Tiles, slates, roofs, felts, millboard, asbestos paper, etc.	—	—	—	—	32,000	20·8	32,000	17·4
Asbestos cement	—	—	3,500	46·7	69,000	44·9	72,500	39·4
Fire-resistant insulation boards	13,500	60·1	—	—	6,500	4·2	20,000	10·9
Insulations—including spray	7,000	31·1	500	6·7	5,000	3·2	12,500	6·8
Jointings and packings	—	—	—	—	10,000	6·5	10,000	5·4
Textiles and spinning	—	—	500	6·7	13,500	8·8	14,000	7·6
Friction materials	—	—	—	—	10,000	6·5	10,000	5·5
Moulded plastics	1,000	4·4	—	—	5,000	3·2	6,000	3·2
Battery boxes	—	—	2,000	26·6	—	—	2,000	1·1
Re-export	1,000	4·4	1,000	13·3	3,000	1·9	5,000	2·7
	22,500	100	7,500	100	154,000	100	184,000	100

N.B.: All tons are 2,240 lb.

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nly other source of crocidolite of

Imports of asbestos—1964

	Chrysotile		Total	
%	Tons	%	Tons	%
—	32,000	20·8	32,000	17·4
6·7	69,000	44·9	72,500	39·4
—	6,500	4·2	20,000	10·9
6·7	5,000	3·2	12,500	6·8
—	10,000	6·5	10,000	5·4
6·7	13,500	8·8	14,000	7·6
—	10,000	6·5	10,000	5·5
—	5,000	3·2	6,000	3·2
16·6	—	—	2,000	1·1
3·3	3,000	1·9	5,000	2·7
0	154,000	100	184,000	100

2,240 lb.

5. World production has risen steeply in the past 30 years and is now in excess of 3,000,000 tons annually, including the considerable but not precisely known production in the U.S.S.R.

6. The United Kingdom imports in recent years have varied between about 120,000 and 185,000 tons per annum. The greatest tonnage increase has been in chrysotile (80 per cent total) though the greatest relative increase has been in amosite; the quantity of crocidolite imported has varied around 7,000 tons annually for the last few years and is much less than other varieties.

7. The analysis in Table 2 showing the uses to which asbestos is put is based on information supplied by Dr. Smither.

The estimated population employed in Britain on processes involving asbestos

8. Some information is available to the Panel from the Board of Trade Census Office on the number of persons employed by firms in the asbestos industry which employ ten or more persons.

TABLE 3

Year	Number employed in asbestos industry
1935	6,425
1948	14,445
1954	16,500
1958	18,700
1963	19,600

9. The findings of a recent survey undertaken by HM Factory Inspectorate to estimate the number of workers employed on processes involving the use of asbestos or products with an asbestos content have also been made available to us. In this survey, no estimate was made of fortuitous exposure or exposure arising from the use of a material whose asbestos content was not self-evident (and there are believed to be many such materials). Complete information was also not obtained on the total number employed on lagging and insulation work.

10. The survey indicated that there are some 300 registered factories to which (or to a department or process of which) the present Asbestos Industry Regulations 1931 are applied. These factories were estimated to employ approximately 12,000 persons on asbestos processes or to be otherwise at risk. In some instances, this was all those employed, in the majority of instances, only a proportion and commonly, only a very small proportion indeed. The total is appreciably smaller than the BOT census but it is likely that the latter includes all employees including office staff excluded by the Inspectorate. The production of asbestos cement products, the making of asbestos textiles and of brake lining for motor vehicles were the principal forms of employment in this group subject to Regulations.

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TABLE 4

Factories and warehouses handling asbestos occasionally where Asbestos Industry Regulations have not applied.

1. Electricity generating	lagging and de-lagging
Steel	lagging and de-lagging
Heavy engineering	furnace insulation
Loco building, Railway carriage building	heat and sound insulation
Boiler making	heat insulation
Paper	manufacture of filter papers and grinding of rollers
Electrical Engineering	insulation wiring and preparation of insulation panels
Linoleum, Floor tiles, Rubber, Paints, Plastics, Adhesives, Roofing compounds	used as a filler
Motor assembly	incidental grinding in assembly of brake and clutch parts
Motor vehicle repair	repairs to brake and clutch parts
Building trades	trimming of asbestos/cement sheets and insulation boards
Furniture	substitute for plywood
Scientific	insulation
Light engineering	making of asbestos washers and gaskets

2. *Contractors carrying out work involving use of asbestos may be found in*:

Dock yards
Shipbuilding
Ship-repairing
Generating stations
Installation of plant in heavy industries, e.g. steel
Large building projects—industrial and domestic—on insulation and repair of heating apparatus in, e.g. schools

3. *Other asbestos exposures may occur in*:

Certain aircraft maintenance activities
Disposal of asbestos/cement waste which may be used e.g. as hard standing in car parks
Car body underseals
Asbestos/asphalt mixes for road surfacings

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11. Many more factories use either asbestos or products containing asbestos intermittently. The preamble to the present Asbestos Industry Regulations (SR & O 1931, No. 1140) specifically excludes their application to "any factory or workshop or part thereof in which the process of mixing of asbestos or repair of insulating mattresses or any process specified in (v) [sawing, grinding, turning, abrading and polishing in the dry state of articles composed wholly or partly of asbestos in the manufacture of such articles] . . . so long as such process or work is carried on occasionally only and no person is employed therein for more than eight hours in any week and no other process specified in the foregoing (not here quoted) paragraphs is carried on." So long as such factories are not registered under an appropriate Code of Regulations their precise number at any time will be in doubt. Workers employed will also vary from time to time both as individuals and in number. It will be impracticable to identify in a meaningful sense, those exposed fortuitously to asbestos dust from processes carried on by others but with improvements in working arrangements such a total is more likely to decrease in future.

12. In the referred to survey by the Inspectorate there were, in addition to those factories attracting the Regulations, an additional 228 factories identified to which the application of the present Regulations was not appropriate. The number of employees in these considered to be directly at risk totalled 1,065 and although some factories were quite large, in none did the asbestos users exceed ten in number. Recognising however for the reasons stated above the difficulties in obtaining accurate information on all factories using asbestos products in this fashion, we are of the opinion that these totals underestimate both the number of such factories and the number of workers at occasional risk.

Some indication of the wide variety of industries and processes in which such occasional use of asbestos may be encountered, is provided by Table 4. This is based largely on the Inspectorate's survey but certain further uses, not all in factories, of asbestos have been provided by members of the Advisory Panel.

13. The Asbestos Industry Regulations do not apply to lagging and insulation operations using asbestos although such use of asbestos attracts regulations 76 and 77 of the Shipbuilding and Ship-Repairing Regulations 1960. There is therefore no precise information on the total number employed on lagging and insulation work in shipyards, generating stations or steel works nor in the unloading of asbestos cargoes in docks. However, it has been estimated by the Thermal Insulations Contractors' Association (TICA) in a communication addressed to one of us that there could be approximately 7,500 people directly employed in the application of thermal insulation and ancillary materials. From information available to the Panel, there might be an additional 1,000 insulators directly employed at HM Dockyards. Even so, from the nature of the work, frequently carried out in difficult conditions, others working in the neighbourhood must also undergo considerable exposure to asbestos.

To sum up, the best estimate we have of persons exposed in the use or manipulation of asbestos is about 20,000 but this does not include those persons exposed by reason of working near where asbestos is manipulated. Information about all persons significantly exposed to asbestos by reason of working in the same area as asbestos workers is lacking.

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Identification of problems

14. At its first meeting, the Advisory Panel identified the problems meriting consideration as being

(*a*) the underlying reasons for the increased incidence in recent years of diagnosed asbestosis.

(*b*) whether there was an increased incidence of lung cancer in an asbestos exposed population in those with no evidence of asbestosis.

(*c*) whether asbestos exposure is associated with an increased incidence of gastro-intestinal cancer.

(*d*) the aetiology of mesothelial tumours

(i) in relation to the presence of asbestos bodies in the lungs and

(ii) an occupational history of asbestos exposure

(*e*) an examination of the evidence pointing to crocidolite being of particular significance in the aetiology of mesotheliomata associated with asbestos exposure.

(*f*) the relative biological significance of the asbestos fibre, asbestos particle and total mass of inhaled and retained asbestos in the production of asbestosis and the possibility of determining a threshold limit value.

(*g*) the role of periodic medical examinations, possibly including evaluation of pulmonary dysfunction in the early diagnosis of asbestosis and prevention of complications.

(*h*) the possibility of providing prospectively, a scheme for defining the population of asbestos-exposed workers and maintaining information on their health and its relation to measurements of dust exposure.

Papers have been submitted by Medical Branch of HM Factory Inspectorate and by individual members on those problems and considered by us in subsequent meetings.

The increasing incidence of asbestosis

15. Apart from the excellent and detailed medical records maintained by certain large users in respect of their own employees, the main sources of data on a national or near national scale are:

(*a*) The records of the Pneumoconiosis Medical Panels of the Ministry of Social Security of accepted claims for industrial injuries benefit. These records are the most accurate currently available but do not include those cases who, for some reason or another, do not seek injuries benefit or who escape any arrangement for periodic examination and diagnosis. Where payment of death benefit for asbestosis is made, such payments are not shown separately from those for other forms of pneumoconiosis.

(*b*) A search of all death certificates for those recording asbestosis as a primary cause of death or as an important condition present. This has been over many years, a joint exercise of the Registrars-General and Medical Branch of the Inspectorate. The position up to the end of 1964 has been summarised in the Annual Report for 1964 of HM Chief Inspector of Factories on Industrial Health. Table 6 which also gives the corresponding information for 1965 and 1966, is modified from that Report.

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TABLE 5

Asbestosis—Ministry of Social Security diagnosed cases

Year	Diagnosed at initial exam.	Diagnosed on re-examination	Total
1954	31	—	31
1955	48	—	48
1956	31	—	31
1957	51	5	56
1958	25	2	27
1959	35	2	37
1960	29	—	29
1961	42	1	43
1962	51	1	52
1963	63	4	67
1964	81	2	83
1965	79	3	82

TABLE 6

Death certificates recording asbestosis
percentage of cases with an intra-thoracic tumour

Period	Males			Females		
	Asbestosis —all deaths	Asbestosis with cancer of lung	Percentage with cancer of lung	Asbestosis —all deaths	Asbestosis with cancer of lung	Percentage with cancer of lung
1924–1930	13	—	Nil	7	—	Nil
1931–1940	66	13[1]	19·7	82	5	6·1
1941–1950	92	21[2]	22·8	45	5[1]	11·1
1951–1960	144	45	31·3	40	11	27·5
1961–1964	113	62[3]	54·7	26	7[4]	26·9
1965	46	19[5]	41·3	18	5[6]	27·8
1966	54	35[7]	64·8	10	7[8]	70·0
1924–1966	528	195	36·9	228	40	17·5

1 Includes one case recorded as "cancer of pleura".
2 Includes one case recorded as "sarcoma of pleura".
3 Includes eleven cases recorded as "mesothelioma of pleura".
4 Includes two cases recorded as "mesothelioma of pleura".
5 Includes nine cases recorded as "mesothelioma of pleura".
6 Includes three cases recorded as "mesothelioma of pleura".
7 Includes 14 mesotheliomas [In addition, two cases of peritoneal mesothelioma].
8 Includes two mesotheliomas [In addition, two cases of peritoneal mesothelioma].

In the absence of a scheme for medical examinations of all asbestos workers, some victims of the disease, at least in its less severe form, will die unrecognised. Data based on death certificates thus provide minimal figures.

16. These data presented in Tables 5 and 6 indicate beyond reasonable doubt that there has been in recent years a rising diagnosis of cases of asbestosis. It is necessary, however, to view such recorded increases against the increase in the consumption of asbestos and numbers of workers employed in the industry or indirectly coming into contact with asbestos during the past two or three decades.

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There is some reason to believe too that the clinical criteria for diagnosis have changed in this period of time. In particular, there is currently a tendency to record as a case of asbestosis, minimal degrees of the disease in the presence of one of those neoplasms recognised as frequently complicating asbestosis.

17. Merewether, [2] summing up in 1930 in his 'Report on Effects of Asbestos Dust on the Lungs' expressed the view that 'in the space of a decade, or thereabouts, the effects of energetic application of preventive measures should be apparent in a great reduction in the incidence of asbestosis'. This prophecy unfortunately, has not been fulfilled. McVittie[3] has reported that of 247 new cases of asbestosis diagnosed between 1955 and 1963 by four Pneumoconiosis Medical Panels, no fewer than 165 or 67 per cent., had entered the industry in 1933 (by which time the Asbestos Industry Regulations were fully operative) or at a later date.

TABLE 7

New cases of asbestosis diagnosed 1955–1963, *analysed by date of entry into industry*

(McVittie—New York Symposium on Biological Effects of Asbestos)

Principal occupation	Entered industry before 1933	Entered industry 1933 or after	Total
Opening, disintegrating	3	38	41
Insulating:			
Laggers	41	31	72
Sprayers	1	12	13
Mattress makers	2	3	5
Others	3	9	12
Weaving	6	10	16
Carding, spinning, etc.	10	27	37
Slab and pipe making	3	17	20
Brake lining	3	1	4
Miscellaneous	10	17	27
TOTAL	82 (33%)	165 (67%)	247 (100%)

18. The significance of 1931 (or 1933) as a base year should not however be overrated. The Asbestos Industry Regulations made in 1931 and becoming fully operative on 1st January 1933 only apply, as we have remarked, to certain uses of asbestos, including the processes of manufacture of asbestos containing articles and asbestos spinning and weaving and other processes incidental to these, and the production of asbestos cement products. Although the survey by the Inspectorate indicates that many, probably a large majority, of the workers using asbestos come within the scope of these Regulations, laggers, the total of whom is not known with any accuracy, tend to be excluded. McVittie's data show very clearly that lagging using asbestos can be a hazardous occupation.

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ered industry 933 or after	Total
38	41
31	72
12	13
3	5
9	12
10	16
27	37
17	20
1	4
17	27
165 (67%)	247 (100%)

base year should not however be
is made in 1931 and becoming fully
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and other processes incidental to
t products. Although the survey by
ly a large majority, of the workers
e Regulations, laggers, the total of
d to be excluded. McVittie's data
can be a hazardous occupation.

19. The Report of the Ministry of Pensions and National Insurance, 1965 (Cmnd. 3046) records that the Pneumoconiosis Medical Panels undertook 1,840 initial examinations and 2,729 periodic medical examinations, of which 1,087 and 1,109 were in the asbestos industry. These examinations were performed under the Silicosis and Asbestosis Medical Arrangements Scheme.

20. We have considered carefully the foregoing evidence of a growing incidence of asbestosis preceded however, in time, by an increase in overall consumption of asbestos and a rising population of exposed workers. The fact that the medical supervision of workers in the asbestos industry originally recommended by Merewether was not extended to workers in new processes as these were introduced, makes us unable to conclude with conviction whether the increase in diagnosed cases can be explained by the effects of the other factors mentioned above or whether there has been an actual increase in the attack rate or a combination of these effects. On general considerations, we are inclined to accept the growing use of asbestos as the most probable explanation of the increase in cases. However, we also feel bound to record that conversely there is no evidence pointing to a decrease in the attack rate in the industry as a whole although there is such evidence in certain important asbestos using factories.

21. We note, however, that at the present time there is no evidence pointing to the occurrence of significant asbestosis elsewhere than in those identified industries where asbestos is extensively used. Clearly, this opinion is not to be applied to the problems of certain other effects of asbestos exposure, notably the development of mesothelial tumours.

Asbestosis and cancer of lung or bronchus

22. It is now generally accepted that there is an excess incidence of lung cancer in those dying with asbestosis. The lung tumour may be the actual cause of death or an incidental finding at autopsy. The proportion of cases with this combination would appear to be increasing and in some current series (e.g. Table 6) is around 50 per cent. However, it is by no means certain that in comparison with earlier data, like is being compared with like. The view most widely held in Britain is that the excess of lung cancer is associated with asbestosis and not merely asbestos exposure. However, it has been claimed by Selikoff[4] and his co-workers who found 45 deaths against an expected number of 6·6 due to cancer of the lung or pleura in a group of 632 insulation workers studied that there is an excess mortality from lung cancer in the absence of asbestosis, only 12 of the group having asbestosis. Doll[6] (1955) reported a study of workers in a large asbestos works where exposure is mainly to chrysotile. The cause of death, as determined at necropsy was obtained in 105 persons. Lung cancer was found in 18 instances, 15 times however in association with asbestosis. 113 men who had worked for at least 20 years in places where they were liable to be exposed to asbestos dust were followed up. There were 39 deaths in this group against 15·4 expected, including 11 cancer of lung deaths against 0·8 expected.

23. Dr. Knox[6] a member of the Advisory Panel, in collaboration with Doll and I. D. Hill, has since shown that there has been a reduction in the mortality rate in this factory with no excess of deaths from lung cancer in workers employed for the first time after 1933. Doll had observed in his own paper that the

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average risk became progressively less as the duration of employment under the old dusty conditions had decreased. Dr. Knox has kindly made available for the Advisory Panel his data up to mid-1964 and these are produced in Table 8 and show a continuance of the favourable trend previously reported by him and his collaborators.

TABLE 8

Group	Description	Number of persons	Number of deaths					
			All causes		All neoplasia		Cancer of lung and pleura	
			Obs	Exp	Obs	Exp	Obs	Exp
1	20-year men over 10 years before 1933	57	45	16·22	19	3·56	15	1·06
2	20-year men 5–10 years before 1933	45	16	11·28	8	2·70	5	1·01
3	20-year men 0–5 years before 1933	16	3	2·54	1	0·66	1	0·27
4	20-year men Entered 1933 or later	104	10	6·38	1	1·73	1	0·78
5	10-year men Entered 1933 or later	489	56	56·74	11	14·25	6	5·78
6	10-year women Entered 1933 or later	190	8	6·07	2	2·16	1	0·15

In this table "20-year" men refers to those employed in Scheduled Areas of the Textile Asbestos Industry for 20 years and upwards, and "10-year" persons similarly refers to those so employed for 10 years and upwards. The men in group 4 are included in group 5. For definitions of these various groups reference should be made to the original paper by Knox, Doll and Hill (serial 6, list of references).

In none of the groups employed since 1st January 1933 when the Regulations became effective, is there an excess mortality from lung cancer or cancer of other organs. The female death in category 6, recorded as lung cancer was found to be due to an alveolar cell carcinoma, a rare variety not usually considered occupational.

24. We have given some thought to the question whether the development of a lung cancer is an occupational hazard to asbestos workers even in the absence of demonstrable asbestosis. The possibility of such an association rests almost entirely on the claims of the American investigators and it is a fair comment that the evidence on which they make their claim is incomplete in that it has not always been based on autopsy examinations. In the opinion of those members of the Advisory Panel with experience of the medical care of asbestos workers,

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ɔx has kindly made available for
ıd these are produced in Table 8
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Number of deaths

ɔs	All neoplasia		Cancer of lung and pleura	
xp	Obs	Exp	Obs	Exp
·22	19	3·56	15	1·06
·28	8	2·70	5	1·01
·54	1	0·66	1	0·27
·88	1	1·73	1	0·78
5·74	11	14·25	6	5·78
5·07	2	2·16	1	0·15

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there has been no excess of lung cancer in the absence of asbestosis in the workers under their care. This view is also the most widely held one in Britain today and we have no other evidence with which to challenge it. In particular, the prospective study to which we have referred in para. 22 gives cause for reassurance.

25. This prospective study will need to be pursued for some years yet to ensure that the present trend is being maintained before it can be concluded beyond doubt that the improved factory conditions have eliminated all risk of excess bronchial cancer from industrial exposure. It is however encouraging and suggests that the hazard from asbestos can be controlled by hygienic measures to a point where cancer of the lung need not be feared, at least where chrysotile, the variety of fibre mainly in use at the factory concerned, is in use.

Carcinoma of the gastro-intestinal tract and asbestos

26. It has been claimed by certain American investigators[7] that there has been a high incidence of gastro-intestinal cancer in a group of insulation workers studied by them. In a series of 307 consecutive deaths among 1,522 asbestos insulation workers in the period 1943–64, they found 34 gastro-intestinal cancers. These same authors had earlier recorded 29 such deaths against an expected 9·4 deaths.

27. These findings are not supported by two British reports. In the series from which there are death certificates particulars (para. 15) only 11 certificates out of 556 collected up to the end of 1963 recorded a gastro-intestinal cancer[8]. An additional eight certificates recorded a cancer of some other abdominal organ, including the ovary (perhaps mesothelioma). Doll[5], too, in the study referred to found only four neoplasmas of all sites other than lung cancer. Three of these were cancers of the gastro-intestinal tract which is reasonably close to the 2·3 cases expected.

28. We have considered these apparently conflicting reports. While it might be argued that gastro-intestinal cancer is a hazard of asbestos exposure and that therefore, an excess might be overlooked in a series of death certificates relating only to asbestosis, this argument would not be applicable to Doll's series which included all deaths in an asbestos population.

The experience of those members of this Advisory Panel who have had asbestos exposed populations under surveillance for years is also in support of the view that there is no association in Great Britain between asbestosis or asbestos exposure and a high incidence of gastro-intestinal cancer. Moreover, the American findings are open to the same criticism as we have made in para. 23 in that they are not all based on biopsy or autopsy findings. We consider, therefore, that British experience at the present time does not indicate an excess of gastro-intestinal tumours if mesotheliomas are excluded, but further epidemiological studies are needed.

Mesothelioma

29. The occurrence of mesotheliomas with a history of exposure to asbestos has been increasingly recorded in recent years. The extent to which this increase, which shows signs, in a relative sense, of being explosive, is real and how much follows better case findings or diagnosis, is crucial.

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30. From time to time, there have been published references (particularly from London Hospital workers) to the occurrence of cancer of the ovary, peritoneum or pleura in association with asbestosis. Possibly the earliest of these, by Gloyne[9], was in 1933. The author, in discussing the complications and sequelae of pulmonary asbestosis referred to one case of abdominal cancer and another with cancer of the pleura without however, attributing either to asbestos exposure. Keal[10] (1960) reported a series of female patients as having asbestosis, 23 in all, diagnosed at the London Hospital between 1948 and 1960. Four were known to have died of lung cancer, nine with intra-abdominal neoplasms, four with peritoneal growths possibly of ovarian origin, two with an ovarian cancer and four with "carcinomatosis peritonei". From other reports of the occurrence of pleural or peritoneal tumours may be mentioned that by Bonser *et al.*[11] (1955) who noted four peritoneal cancers (one male, three females) in a series of 72 autopsies of asbestosis cases and eight others with no asbestosis but with numerous asbestos bodies in their lungs. This, the authors point out, was a very high incidence in such a relatively small series.

31. Current concern that we are dealing with a specific effect of asbestos dust which is apparently unrelated to whether or not asbestosis is present may be dated from the report by Wagner[12] and his co-workers (1960) of their findings in South Africa. In this series of 33 cases, (22 males, 11 females) in only eight was there evidence of asbestosis but 18 were born in the vicinity of asbestos mines and two came there early in life. The point of special significance was that all but one had a probable exposure to crocidolite, the majority in one area in the North Western Cape Province.

Wagner[13] (1963) was later able to refer to over 120 cases of diffuse mesothelioma of the pleura collected in South Africa and confirmed either by biopsy or at autopsy. All had been recorded since 1956. Primary peritoneal tumours had also been observed. Of these 120 cases, 110 had been exposed to crocidolite. More than half these cases had never worked in the industry but had lived in the vicinity of the crocidolite mines and mills. The association appeared, therefore, to be with exposure to the dust produced in the course of mining and milling asbestos in this area or with living in the area where mining and milling is undertaken.

32. The evidence of an association between asbestos exposure and mesothelioma was reviewed in some detail in February 1964 at an internationally attended meeting of the Occupational Health Committee of the Medical Research Council. Papers were presented describing investigations in various centres in Britain.

There was wide agreement that evidence of exposure to asbestos either through occupation or from detection of asbestos bodies in pulmonary tissue was available in many cases of mesothelioma. In October 1964, much existing information on asbestos and mesothelioma was brought together and amplified at the Conference on Biological Effects of Asbestos held under the auspices of the New York Academy of Sciences. The Proceedings[14] of this Conference have now been published. Primary malignant neoplasm of the mesothelium (diffuse mesothelioma) of the pleura or of the peritoneum in relation to certain occupations involving exposure to asbestos was prescribed for industrial injuries benefit by the Minister of Social Security on 22nd August 1966.

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33. This growing evidence linking many mesothelial tumours, both of peritoneum and pleura with exposure to asbestos, apparently of slight degree or remote in time, constitutes, in our opinion one of the most serious aspects, particularly from a public health point of view, of the asbestos problem. Already, an important report[15], with which one of our members, Dr. Newhouse, has been closely associated, of mesothelial tumours either associated with asbestos exposures arising in the home or from residence in the region of an asbestos factory has appeared and aroused considerable public comment. Some evidence of a similar type has recently come from the USA[16] and Germany[17].

34. For some time now, the Pneumoconiosis Research Unit of the Medical Research Council has been maintaining a National Register of all cases of mesothelioma occurring in this country. This Register which already contains particulars of over 200 cases has been handed over to the Medical Branch of HM Factory Inspectorate. We urge that Medical Branch should continue to keep the Register up-to-date. A note on how this might be achieved, and prepared by the Pneumoconiosis Research Unit, is reproduced as Appendix II to this Report.

We recommend that working histories should be obtained of these cases in some detail, thus enabling them to be classified into:

(*a*) those with a definite history involving the use of asbestos;

(*b*) those with the possibility of a fortuitous exposure to asbestos in the course of their employment which did not directly entail the use of asbestos. In this group might be included details of family exposures if any and residence in relation to asbestos using factories;

(*c*) those with autopsy evidence of asbestos exposure (by identification of bodies containing asbestos fibres in pulmonary tissue) but no recognisable occupational exposure, and

(*d*) a residue with neither pathological nor occupational evidence of asbestos exposure.

Where available, a portion or thin section of tumour tissue should accompany each working history.

35. Such information, if sufficiently detailed would, we consider, be of value in giving more information about asbestos exposure in the genesis of mesothelial tumours in this group. There can be no doubt about the major significance of asbestos or asbestos-linked material in the aetiology of this still uncommon variety of tumour, but it has yet to be proved that there are no other factors.

36. Mention is needed of the significance to be attached to the identification of asbestos bodies in such cases. Reports [18][19] are indicating that asbestos bodies are much commoner than was previously suspected in consecutive autopsies in various parts of the world. All studies so far have shown a significantly higher prevalence of asbestos bodies in those with mesothelial tumours. There is a general belief among pathologists that the bodies they are reporting are due to asbestos. There is need, however, to add the proof of positive identification of the fibres when techniques for doing this have been perfected. Other filamentous

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fibres may occasionally produce very similar bodies in the lungs. The significance in finding an occasional asbestos body in establishing the aetiology of a case of mesothelioma may thus be open to reasonable doubt.

37. It seems important to us that the problem of mesotheliomas in association with asbestos exposure or asbestosis should however be kept in proper perspective. The great public interest being taken in these tumours at this time may otherwise readily develop into a stage in which their importance as a hazard even to asbestos workers may become, in a relative sense, exaggerated.

Much has been written about the mesothelioma problem as it affects the public at large either from accidental exposure to asbestos dust produced by others or even through residence in the neighbourhood of an asbestos factory. We do not at the present time know the precise incidence of mesothelioma in the population generally. The total of mesothelioma cases collected over a period of many years in Great Britain is around 200, most of which have been diagnosed in the last fifteen years. The incidence is certainly rising but even so, the total must be viewed against a total of 21,476 deaths in males and 3,895 deaths in females in 1964 alone from cancer of the trachea, bronchus and lung. In the last six months 17 cases of mesothelioma have been reported to the P.R.U. but these figures are known to be an underestimate for the country.

Has crocidolite a specific role in production of mesothelial tumours?

38. We have already alluded in the opening paragraphs of this Memorandum to the possibility that crocidolite has a special significance in the aetiology of mesotheliomata.

(*a*) The most convincing direct evidence that this is so is Wagner's[12] [13] series of South African cases in which all but one could have been exposed to crocidolite, only one to chrysotile exclusively and none to amosite.

(*b*) Other evidence indirectly points to a specific effect of crocidolite. We think, for example, that it may well be significant that few mesothelial tumours have been identified in Rochdale, a principal consuming area for chrysotile. A follow-up study[20] of workers from a South Wales factory using mainly chrysotile also led the authors to suggest that chrysotile might not be a serious hazard so far as mesothelioma was concerned, although there had been at this factory a slight excess in the number of deaths from lung cancer. Whether asbestosis was also present in these cases is not recorded. Finally, we are impressed by the relative frequency with which mesotheliomas have occurred at one London asbestos factory where all types of asbestos are used[21], but cases from all other areas now exceed the number diagnosed in London.

(*c*) By and large, however, British exposures to asbestos are too mixed in character to enable us to identify with confidence pure exposures and we must look overseas to countries where only one type of asbestos is largely used. Thus, very few cases of mesothelioma have been reported in the asbestos workers in Quebec, (one of the world's principal sources of chrysotile) and none in Southern Rhodesia (Shabani) or Swaziland (Havelock).

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39. Not all the evidence points towards crocidolite only being concerned. Webster[22] has suggested that some other factor either alone or in association with asbestos, should be considered. In South Africa, although the chemical composition of the North West Cape and Transvaal crocidolites is similar no case of mesothelioma has been found in people exposed only to the Transvaal crocidolite. Production in the Transvaal however is relatively small compared with that of the North West Cape. American investigators[23] who have examined the relationship between exposure to asbestos and mesothelioma in the USA have stated that in the past crocidolite consumption there was a negligible proportion of the total asbestos consumption, leading them to suggest that mesothelioma is a neoplastic hazard of asbestos exposure and not necessarily a problem only of crocidolite. Wagner[24] of the Pneumoconiosis Research Unit, has produced experimental mesothelial tumours in rats not only with crocidolite but also with amosite and chrysotile. Amosite, to which crocidolite is closely related both structurally and chemically has not been associated with mesotheliomas in South Africa, its only commercial source of supply. However, the mining of amosite is more recent than that of crocidolite and it may be that insufficient time has yet elapsed for the development of mesotheliomas due to this fibre.

40. At a meeting following the Symposium on Biological Effects of Asbestos in New York in 1964, the Working Group on Asbestos and Cancer of the International Union against Cancer expressed its views on this extremely difficult problem in these words: "In the case of mesotheliomas evidence from certain countries suggests that exposure to crocidolite may be of particular importance but it cannot be concluded that only this type of fibre is concerned with these tumours and further investigations of this problem is needed"[25].

41. These words aptly sum up our own views on the aetiology of mesotheliomas. However, we feel we must go a bit further and pose the question "Can we in the light of the existing evidence incriminating crocidolite afford to wait, perhaps for several more years, until pure population studies give a final answer to this problem?" This we appreciate is not solely a medical question, but we feel it is within our competence to recommend that, unless special considerations operate, crocidolite should wherever possible be replaced by another variety of asbestos and whatever measures may be adopted to control asbestos dust, these must be even more rigidly applied to crocidolite.

Medical supervision and examination of workers exposed to asbestos

42. The Report[2] by Merewether and Price recommended "the control of the disease by periodical medical examinations of the workers by which those unfitted by health reasons are prevented from entering the industry, and cases of fibrosis and pulmonary tuberculosis are detected at the earliest possible moment. The ultimate and only reliable test of the effectiveness of the preventive measures adopted in the industry will be found in the statistics derived from the records of periodical medical examination of the workers . . . ". The Asbestos Industry Regulations and a scheme for initial and periodic medical examinations with provision of compensation within the Workmen's Compensation Acts for those asbestos workers with asbestosis shortly followed.

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The statement of Merewether and Price remains true but the hopes expressed in it have not been fulfilled in our opinion for two reasons:

(*a*) the Asbestos Industry Regulations 1931 dealt with the position as it was then and have not been extended to cover uses of asbestos developed since 1931;

(*b*) the necessary statistics could not be obtained from the system of periodic medical examinations introduced. In particular, examinations covered a limited field of employment with asbestos and there were no official records of the total number of exposed persons. A few reports from individual factories show that good records can provide evidence of the type needed.

43. We have given careful thought to the role and value of medical supervision and examinations of asbestos workers as a means of preventing or securing early treatment of asbestosis in the light of current circumstances. Our views on two non-controversial aspects are summarised as follows:

(*a*) The respiratory status of persons entering the industry should be established before exposure starts. To our mind, this is a full justification for pre-employment (or pre-exposure) examinations but it also allows consideration of fitness for work. We would hesitate, however, to state how early a stage of a common condition such as chronic bronchitis should lead to exclusion from the industry.

(*b*) There remains a need for a procedure to enable claimants for industrial injuries benefit to undergo an appropriate medical examination to assess their degree of disability on which the amount of compensation will depend.

44. The value of periodic medical examinations and assessments in preventing or controlling the development of the disease requires further consideration.

(*a*) *The prevention of mesothelioma.* If mesothelioma is an expression of a primary tumourogenic effect medical supervision would seem to have little part in prevention. Logically, prevention is by substitution and even if this is possible in the future, for persons currently exposed or exposed in the past, the risk is likely to remain after exposure has stopped. On this point there is some evidence that the risk of mesothelioma does not decline rapidly after ceasing exposure as does the risk of lung cancer after giving up cigarette smoking. At the moment the prognosis is hopeless and early diagnosis academic but future advance in therapy might make early diagnosis a factor of significance.

(*b*) *The prevention of bronchial carcinoma.* Much must depend on whether this is thought to be directly due to the action of asbestos as a carcinogen or a complication of the fibrosis of asbestosis, a fundamental matter which we have already considered (paras. 22–25). If asbestos is a true carcinogen, there may be an undetected public health problem at least comparable to that believed by many to exist with mesothelioma but much more difficult to establish. It would be likely however that the risk would be greater in those occupationally exposed and periodic medical examination in the hope of detecting the carcinoma when the prognosis is still not hopeless, might be justifiable. If carcinoma follows the fibrosis of asbestosis, the value of medical examination will be as for the control of asbestosis itself.

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(c) *Periodic medical examinations as a means of controlling the evolution of asbestosis* would have a logical basis if it is accepted that this disease is not necessarily progressive or that its rate of progress is variable and a reflection on working conditions. Some of the evidence presented however suggests that once the disease has appeared, it tends to run a progressive course to death although this may not be true in all circumstances. The improvement in the mean age at death in asbestosis cases in more recent times as shown by scrutiny of death certificates is largely explained by the elimination of the deaths in the relatively young due to tuberculosis. There is no improvement in the mean age at death where carcinoma has been a complication.

45. Dr. Caplan has provided particulars of 430 cases of asbestosis certified by four pneumoconiosis panels in the last ten years. Dr. Newhouse has made a preliminary examination of these data. The age distribution at certification is given in Table 9.

TABLE 9

Age distribution of 430 *cases of certified asbestosis*

	Age (years)				
	31–40	41–50	51–60	61–70	All ages
Number of cases	38	112	209	71	430

The survival rates of 430 cases are given in Table 10. About 80 per cent of these cases had been in the industry for ten years or longer.

TABLE 10

Survival rates of 430 *cases of asbestosis (all ages) certified by pneumoconiosis medical panels between* 1956–1965

Year after certification	Probability of surviving each year	Probability of dying each year	No. alive on each anniversary	No. dying during each year
x	px	qx	lx	dx
0	0·877	0·123	1,000	123
1	0·934	0·066	877	58
2	0·915	0·085	819	70
3	0·929	0·071	749	53
4	0·933	0·067	696	46
5	0·906	0·094	650	61
6	0·953	0·047	589	28
7	0·969	0·031	561	18
8	0·900	0·100	543	54
9			489	

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The survival rates per 1,000 persons at five years and nine years have also been calculated for persons certified at 50 years or younger and at 51 years or older. These are:

	All ages	Certified at	
		50 years or younger	51 years or older
5 years	650	729	608
9 years	489	668	380

These mortalities are about two or three times that of the general male population of equivalent ages. The data is being further examined by Dr. Newhouse, who will be checking at the source as some of the figures for certified cases for individual years differ from those reported by McVittie[3].

46. If the data given in the preceding paragraph are to be accepted as typical for all cases of asbestosis (and this is not necessarily so for the disease as it occurs in the large numbers of asbestos workers not at present medically examined), serious doubt must inevitably be cast on the value of conventional periodic medical examinations.

There is normally a mean latent period of 15–20 or more years, in large measure unaffected by the age at entry to the industry, before a diagnosis based on radiological changes and detection of abnormal clinical signs becomes possible. The study of departures from normal pulmonary function during this lengthy induction period has only become possible during the past few years. Yet it is possible that a stage may be determined in the silent pre-clinical development of asbestosis at which the disease, provided further exposure is brought to an end, will not progress. If we are correct in our view on the aetiology of bronchial carcinoma in asbestosis, such an individual will also be likely to be spared that malignant complication.

47. We would like to record here that periodic medical examinations for prevention have a different purpose to those designed to assess entitlement to benefits; different objectives are involved which may well require a different approach to that adopted for compensation purposes. We regard the acceptance of this distinction as of great importance—indeed the bigger the 'gap' between the two sorts of examination, the greater the contribution to prevention. Early detection will depend on improved X-ray techniques and interpretation and on evidence of deterioration of pulmonary function. We know that research into the application of pulmonary function tests in the early diagnosis of asbestos is being undertaken. We note here that it has been claimed[26] that asbestosis can be detected by such tests before it is apparent on X-ray films and that men removed from exposure four to five years previously, when the signs of asbestosis were minimal, have maintained a reasonably functional level when compared with similar men who remained exposed to asbestos.

48. We are aware that the implementation of the ideas contained in para. 44 implies that:

(*a*) the number of workers to be examined and the frequency of such examinations will increase considerably particularly after the first few years of employment. Further we suggest that the practical implementation of

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[redacted]

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rs or younger and at 51 years or

Certified at	
ears or unger	51 years or older
729	608
568	380

times that of the general male being further examined by Dr. is some of the figures for certified orted by McVittie[8].

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ed and the frequency of such ticularly after the first few years the practical implementation of

these ideas and the possibility of their resolution, which must even if only because of numbers involved, present organisational problems, should be discussed between the appropriate Ministries, and

(*b*) those affected by asbestosis at the stage of maximum non-progression (if and when this becomes defined) should be recommended to cease further exposure to asbestos.

49. We cannot of course, arbitrarily withdraw groups of asbestos workers from further exposure at different defined stages of development of the disease nor would it be ethical to attempt to do so. There is however a natural labour turn-over in this as in any other industry, and, so long as asbestos continues to be used, it should be possible to obtain populations with varying exposures and development of early changes in lung function at the time they leave the industry. Such a prospective survey implies the preparation and maintenance of a central register of asbestos workers with details of periodic medical findings both during and, if possible, after ceasing exposure to asbestos together with information about each individual's health with the duration and date of cessation of exposure to asbestos. The co-operation of other Government departments, notably the Registrars General to determine the cause of death where it occurs in those named in the Register, will be essential to ensure the success of the study.

50. We would not minimise the problems which such a survey would encounter. Nonetheless, we feel that it would be of very great value as:

(*a*) it will be the final criterion on the adequacy of environmental control measures on which the main hope must lie of controlling the occurrence of asbestosis;

(*b*) it will provide information, unknown at present, of the natural history of the development and early progression of asbestosis and of attack rates;

(*c*) it will be essential in the determination of safe conditions for the use of asbestos;

(*d*) it will provide information about the health implications to the general public of exposure to asbestos.

The Measurement of Air-borne Asbestos

51. We consider that a memorandum such as this would not be complete without reference to the problem of air sampling, including techniques and evaluation of the findings. While any ultimate standard for a harmful agent should be based on biological effect, there are great difficulties in arriving at such a standard in the case of a slow acting long-term toxic or harmful agent and in this asbestos is no exception. There is also the probability that different types of asbestos may have different biological effects or activities.

52. We find that there is considerable variation in practice both in methods of measuring the dust, and the accepted tolerable levels of the parameter chosen.

The first issued standard in this country was that currently published by the Ministry of Labour[27] and derived from the annually published list of threshold limit values of the American Conference of Governmental Industrial

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Hygienists. Although issued notionally as a biological standard this value of 177 particles per cubic centimetre (corresponding to the ACGIH standard of 5 million particles per cubic foot) lacks recent confirmation and includes in its several practical defects, absence of definition of type of sampling instrument (an impinger type is generally used in the USA), sampling strategy or range and type of particles to be sampled. Retention of this value in British practice as a biological standard is almost certainly unjustified, although in its favour originally, it did provide in the USA a guide level albeit largely an arbitrary one. In addition to this numerical standard, HM Factory Inspectorate uses a gravimetric standard of 0·1 milligrams per cubic metre.

The parameter which has been used by member firms of the Asbestosis Research Council is the asbestos fibre; only fibres of length 5–100 microns and length to breadth ratio equal to or greater than 3 to 1 are counted. Fibre counts in two large asbestos textile factories currently range between 2 and 7·7 per cubic centimetre and may account for but two per cent of the total dust count from all causes[28].

If a gravimetric method of sampling is preferred, a concentration of 0·1 milligrammes per cubic metre of air should be regarded as an upper limit of acceptability. Although this level is an arbitrary one, it seems from practice to require for its attainment, a correspondingly high standard of dust control by conventional engineering techniques.

It would be unjustifiable at this stage to exclude the asbestos particle from the field of biological interest. In linking asbestos with malignant disease a truer expression of activity may well be in terms of weight of asbestos, or type of asbestos.

A brief account of the main features of the principal sampling instruments and techniques is given in Appendix I to this Memorandum.

53. In the present state of knowledge we believe that fibre counts are an important parameter for the assessment of the environment. In one textile mill in Rochdale (where the study by Dr. Knox and his co-workers referred to in para. 23 took place) every endeavour has been made to reduce air-borne asbestos by engineering methods, including exhaust ventilation. In this mill fibre counts as follows are achieved on average.

Process	Particle counts per c.c.	Fibre counts per c.c.
Carding	400–600	7·7
Roving frames	200	5·5
Cheese winding	150	5·0
Beaming	150	4·5
Pirn winding	150	3·0
Bag slitting	100	4·3
Mechanical bagging	120	3·8
Doubling	150	2·4
Weaving	125	3·0
Webbing (narrow widths) weaving	120	1·9
Plaiting	150	3·8

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e counts c.c.	Fibre counts per c.c.
1–600	7·7
100	5·5
150	5·0
150	4·5
150	3·0
100	4·3
120	3·8
150	2·4
125	3·0
120	1·9
150	3·8

We suggest that if similar levels can be achieved generally in the asbestos using industries, a great advance will be made. As we have shown in para. 23 and in Table 8, the incidence of lung cancer in such conditions has been greatly reduced over the years and is currently probably within normal expectations. Practical action begins in the step by step reduction of air-borne asbestos to the lowest possible levels and certainly to levels not greater than the above. We would not wish to regard the above levels as standards but would prefer to regard them as immediate goals. As knowledge develops, the goal should be subject to progressive reduction.

54. It is not yet possible to state the risk of developing asbestosis in relation to years of exposure and dose of dust. However, some information which would help in calculating this is, we believe, available in the records of two of the large companies processing the fibre. We recommend that this information be looked at with the aim of providing an interim figure based on the best evidence at present available in this country. The method of expressing the figure requires detailed discussion. We understand that the Standards Committee of the British Occupational Hygiene Society is at present working on this problem. The results of their work may be expected to be of use in developing an agreed national goal. But this will inevitably be an interim figure based on inadequate evidence. Systematic monitoring of the environment of asbestos-exposed workers should be started as soon as possible so that reliable figures may become available 10–15 years ahead.

55. So far as asbestosis (and hence asbestos related bronchial carcinoma) is concerned, we believe that it is possible by the application of the best current engineering practice to create an environment in which the chances of developing asbestosis of a compensatable degree are small. Even here, the question arises as to what is meant by "compensatable asbestosis" as X-ray films fall on a spectrum at one end of which are the gross changes characteristic of frank asbestosis and at the other end, changes which, although due to asbestosis, are slight. Much more research in the standard of diagnosis is required.

56. In the light of present knowledge, we must record our opinion that where asbestos, particularly crocidolite is used, some risk of mesothelioma will have to be accepted. At this time, we do not know the level of exposure below which the risk may be negligible. It seems quite possible that those mesotheliomas which appear to be related to environmental and home exposures were in people who had quite an appreciable dose of asbestos. There is also some evidence, relating to past occupational exposures which supports the view that, if occupational exposures are reduced to the levels indicated in the above paragraph, the risk of developing mesothelioma is greatly reduced. The latent period between first exposure to asbestos and the development of mesothelioma is very long, in some cases up to 30–40 years or more. Cases in South Africa have occurred at a relatively young age apparently following exposure in childhood. Some advantage might be gained in restricting industrial exposure to asbestos to persons over 40 years of age or even older. We recommend that the practicability of doing this should be discussed in different branches of industry.

57. Because the recirculation of effectively filtered air permits more frequent air changes and under existing conditions may be cleaner both in respect of asbestos and other impurities than the outside air, we are in favour of recircula-

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tion. The discharge of dust-laden air from factories is a possible source of hazard to the general population and we recommend that even where there is no recirculation of air in the factory, a similar high standard of filtration should be required for discharged air.

Air-borne dust from asbestos waste dumps is an additional possible source of hazard which requires control.

58. In this Memorandum we have considered evidence and matters of principle in relation to prevention and we recognise that further discussion will be necessary on their implementation.

Summary of conclusions and recommendations of the Advisory Panel

59. (*a*) The number of new cases of asbestosis being diagnosed is increasing (paras. 15–21). Many of these cases are occurring in those sections of the industry to which the Asbestos Industry Regulations do not apply but there is also a substantial number of new cases occurring even in those employed solely since 1933 in sections of the industry to which the Regulations do apply (paras. 17–18). The Advisory Panel considers that the most likely explanation for this rise is the increased use of asbestos and number of people employed in the industry over the past twenty years. However, there is no evidence that the overall attack rate has decreased in the industry over this period, although it certainly has in certain textile mills in which the dust conditions have been greatly improved (para. 20). There is little evidence that asbestosis occurs apart from in those industries in which asbestos is extensively used (para. 21).

(*b*) British experience points to bronchial carcinoma being a complication of asbestosis rather than asbestos exposure. Further work is desirable before this can be proved, (paras. 24–25). There is no British evidence to support American claims of a high incidence of gastro-intestinal cancer in asbestos workers but further investigations are required (para. 28).

(*c*) There is strong evidence linking asbestos exposure with the development of many mesothelial tumours of pleura and peritoneum (paras. 31–33). A National Mesothelioma Register (Appendix II) and the uses to which it may be put are discussed (paras. 34–35). There is evidence already that asbestos has become widely disseminated in the environment (para. 36).

(*d*) The evidence suggesting that crocidolite has a special significance in relation to mesotheliomal tumours is discussed (para. 38) and some conflicting observations also noted (para. 39). The Advisory Panel considers that the evidence to date on balance indicates a particular significance must be given to crocidolite as a cause of mesotheliomas. The Panel recommends that other types of fibre should be substituted for crocidolite wherever possible and where this is at present impossible special precautions should be taken to reduce the risks of inhaling the material to the lowest possible level (para. 41).

(*e*) The objectives and limitations of medical supervision of asbestos workers are discussed (paras. 42–49). Any improvement in the prognosis of asbestosis must depend on diagnosis at an earlier pre-clinical stage at which withdrawal from further exposure may stop progression of the disease (para. 46).

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A system of regular medical supervision of asbestos workers linked with a continuing record of their dust exposure and morbidity and mortality is an essential step in establishing whether or not occupational hygiene measures urgently needed are fully effective (paras. 48–58).

(*f*) Problems encountered in sampling of air-borne asbestos are outlined (paras. 51–53). A biologically based threshold limit for asbestos exposure cannot yet be defined but its establishment should be a long-term objective, (para. 54). Meanwhile a provisional standard or standards based on what can currently be obtained in the best factories should be given to industry (para. 53).

60. We should like to record our thanks to Dr. W. D. Buchanan and Miss N. A. Davis, for the immense amount of work they have done in preparing papers for the Panel, and for the drafting of the Memorandum.

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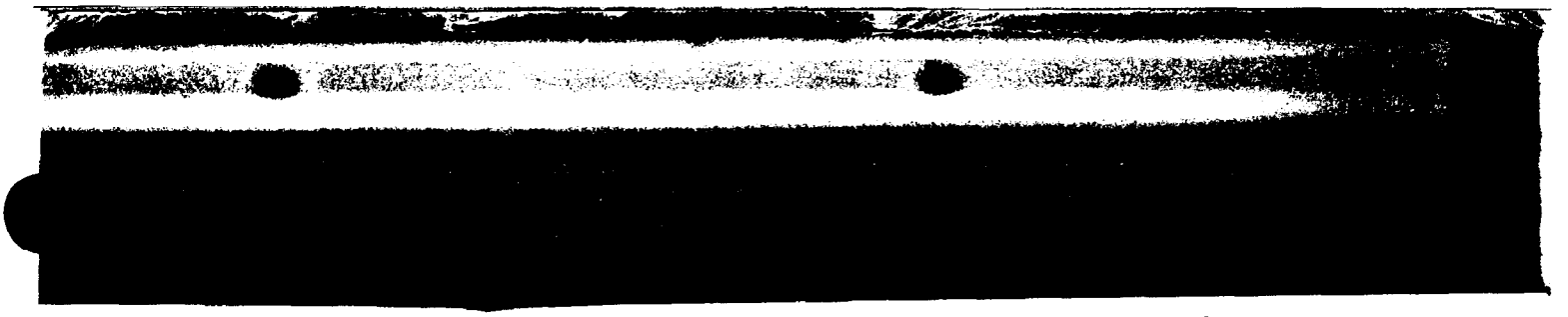
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Appendix I

Current methods of sampling asbestos

Gravimetric

A large volume of air is sampled using a 'Hurricane' sampler, the dust being collected on an ashless soluble filter. After incineration, the asbestos sample is directly weighed, the result being expressed in terms of microgrammes per cubic metre. The Hexhlet sampler is also used.

Gravimetric techniques have the advantages of (*a*) eliminating to a considerable extent the human error in the assessment and (*b*) providing a sample taken over a lengthy period of time which seems more appropriate in a disease of a long period of development.

Particle count and distribution

(*a*) *The long running thermal precipitator* has been widely used by the Inspectorate and provides a sample which can be counted and analysed by particle size. This instrument has proved to be a more satisfactory one for sampling the long asbestos fibres which may be biologically important than the earlier Thermal Precipator which did not sample large particles and long fibres efficiently.

(*b*) *The membrane counter* in its simplest application consists in drawing a measured sample of air e.g. 200 millilitres through a filter of suitable material which is then clarified enabling the trapped particles and fibres to be counted directly by microscopy. This technique is currently in use by member firms of the Asbestosis Research Council.

A modification of this technique in which the membrane filter is actually carried by the exposed worker, being so worn that the air sampled corresponds to that breathed, has been developed. A larger filter is used and a correspondingly longer period of sampling is thus possible.

(*c*) *The Royco electronic counter* has been adopted by the Asbestosis Research Council. Using this instrument it is possible to obtain a continuous series of dust counts at a selected site the results of which are automatically transferred to a tape. The instrument will count, at will, all dust particles up to a pre-determined maximum diameter or any range within this including, if desired, particles of a particular diameter only. It has the advantages of elimination of the human factor in dust counting, speed, and lacks the disadvantage of other counting techniques whose short-term sample may bear little relation to what the worker himself experiences. Disdavantages are the high cost (about £5,000) and lack of portability although the air sampling point need not be at the machine itself. The Royco counter counts all dust particles within the chosen range and does not distinguish asbestos particles from other dusts.

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Appendix II

Note on a National Mesothelioma Register
prepared by the Pneumoconiosis Research Unit on 3rd February 1966

Objects

1. To record the annual number of deaths from mesothelioma of the pleura and peritoneum associated with asbestos exposure.
2. To ascertain trends in the incidence rates.
3. To discover new occupations apparently associated with the tumours.
4. To discover, if possible, tumours occurring without any exposure to known or suspected occupational causes.
5. To provide part of the evidence on which preventive measures should be based.

Sources of information about tumours

1. From death certificates at the R-G.
2. Notification of deaths through the M.P.N.I.
3. Notification of deaths through the M of Labour.
4. Reports through pathologists and clinicians.

Certain selective processes operate through these four sources so that the number of cases will not necessarily be the same, and the use of all four is likely to ensure the most complete cover, both of those believed to be occupationally linked and those in which the occupation was not thought to be involved or in which no adequate investigation of the occupation was made.

The M.P.N.I. are likely to hear about deaths of a majority of the cases of mesothelial tumours occurring in individuals who have applied to that Ministry in life for compensation under the Industrial Injuries Act, but will not necessarily hear of cases in those who were only exposed before 1948. In any case, their records will be biassed towards those in whom an occupational cause is suspect or established.

The M of Labour notifications may include some for whom compensation in life was not sought.

Reports through pathologists and clinicians will include both those occupational and non-occupational cases and will include those who were exposed to asbestos before 1948. In view of the high and rapid mortality of these cases, a majority of these cases detected by the pathologists or clinicians will eventually appear in the R-G's reports, but there may be exceptions. The reports through the pathologists and clinicians have the advantage that they may provide a means for detailed investigation of the occupational histories while the individual is alive, and this could be of considerable help in improving the information about associated occupations and jobs, and so prevention.

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Injuries Act, but will not neces-
posed before 1948. In any case,
whom an occupational cause is

some for whom compensation in

will include both those occupa-
lude those who were exposed to
rapid mortality of these cases, a
gists or clinicians will eventually
exceptions. The reports through
ntage that they may provide a
nal histories while the individual
p in improving the information
prevention.

Suggested procedure for maintaining the National Register

It seems appropriate to build on the scheme already operated by the R-G, the M.P.N.I., and the M of Labour for recording deaths with asbestosis and/or lung cancer in asbestos workers, and supplement this with a scheme for additional reporting to the Medical Department of the Ministry of Labour cases referred to the Panel of Pathologists specialising in the diagnosis of mesothelial tumours set up under the U.I.C.C.

A scheme should be arranged by which the pathologists and/or clinicians send in as full information as possible about identification of the individual and his occupation, including the factory in which he worked, to the Medical Department of the M of Labour who would then follow up the case through their Medical Inspectorate. It is important that these cases reported direct to the M of Labour by clinicians and pathologists should be kept separate from ones reported through the R-G and M.P.N.I. channels, as we shall then see how complete the official collecting channels are.

When and if mesothelial tumours of the pleura and peritoneum become a scheduled disease*, completeness of reporting will be increased, but at least for a while there are likely to be a number of cases arising from exposure years ago which are not caught in an official net.

* Mesothelioma in relation to asbestos exposure was prescribed as an industrial disease by the Minister of Social Security on 22nd August 1966.

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