PLAINTIFF'S EXHIBIT

FD-1618a

Ford Motor Company Limited

Central Office

January 18th 1984.

Eagle Way
BRENTWOOD Essex CM13 3BW
Telex 995311

Mr R.J. Donnellan, Senior Attorney
Office of the General Counsel,
Ford Motor Company,
Parklane Towers West,
One Parklane Boulevard, Suite 300,
Dearborn, Michigan 48126, U.S.A.,

Dear Mr Donnellan,

Subject: **EXPOSURE TO ASBESTOS FROM BRAKE LININGS**

As you are probably aware I had an extended telephone conversation with Mr Krause on Tuesday 10th January 1984, during which, I believe I gave answers to the questions posed in Mr Krause's letter of December 14th 1983.

I enclose the following sets of documents which were requested by Mr Krause

1. Correspondence relating to the 1969 Conference.
2. Internal reports upon which the Ford Conference Papers were based.
3. Correspondence with Mr J. Lynch.
4. Published proceedings of the 1969 Conference.
5. Correspondence regarding commercial developments of the drum cleaning unit.
6. Service information - cars.
7. Service information - trucks.

With regard to question No.9, the Health and Safety Executive have now confirmed to me that while there were internal reports regarding exposure to asbestos from brake linings, there was no public guidance published on the subject, such as Regulations, Guidance Notes etc.

With regard to question No.10, I have written to the firm who developed the drum cleaning unit, to ascertain when this was first marketed in the UK.

I hope that my telephone call and this letter and attachments, give you the information you require, but please let me know if there is any further way in which I can be of assistance to you.

Yours sincerely,

D E Hickish

Dr D.E. Hickish
Industrial Hygiene Specialist.

Telephone Brentwood (0277) 23 3350 Mailing Reference (Please include in Envelope Address) Room 7163

cc: Mr R. Krause.

Registered in England No. 235446 Registered Office: Eagle Way BRENTWOOD Essex CM13 3BW

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PREFACE

Exposure to Asbestos during brake and clutch maintenance

THE PAPERS which follow were originally presented at a Conference held at the Central Office, Ford Motor Co., Brentwood, Essex, on 26 March 1969. The Chairman of the Conference was Dr G. H. Channing, Chief Medical Officer, Ford of Britain, who opened the proceedings by outlining the events which had led to the arranging of the Conference.

Publication of the proposed Asbestos Regulations by the Department of Employment and Productivity had raised queries within the motor industry as to whether clutch and brake maintenance activities, both at the manufacturers' premises and within the repair trade, would come within the requirements of the Regulations. There was a general desire that the subject should be investigated, and any necessary remedial measures sought, in advance of the legislation so that Dealers could be advised and servicing procedures modified where this might be necessary. Investigations had been made by the Industrial Hygiene Units of the British Motor Corporation, and of Ford of Britain, and their findings would be reported to the meeting. These would be preceded by papers on the medical aspects of exposure to asbestos, and later in the programme there would be papers indicating possible solutions to the problems involved.

D. E. HICKISH

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ASBESTOS AND ASBESTOSIS*

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THE FORMS AND USES OF ASBESTOS

COMMERCIALLY important asbestos fibres fall into two main groups. The first of these is chrysotile, and the second comprises the amphiboles. Both groups are fibrous silicates, but they differ in geological origin, in chemical composition, in molecular structure, in fibre size and strength, and in other characteristics. Chrysotile, white asbestos, comes from many different places. There are slight chemical and physical variations in the fibres from different sources, but basically all have the same molecular structure. On the other hand, the amphiboles comprise at least three separate types, whose molecular structure is very similar, but whose chemical and physical properties differ more widely. Amosite (amber) and crocidolite (blue) are of commercial importance in this country, whereas anthophyllite is a Finnish fibre not used here.

The relative amounts of each fibre in world production is shown in Fig. 1 and the areas of main use in Fig. 2.

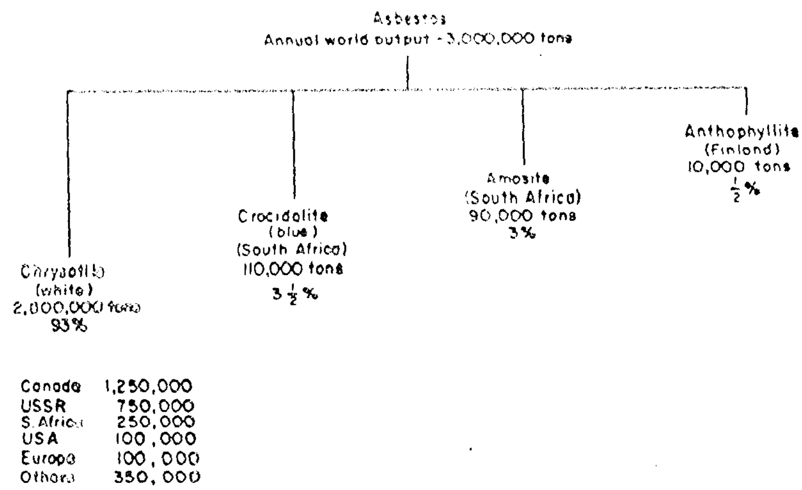

FIG. 1. World production of asbestos.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

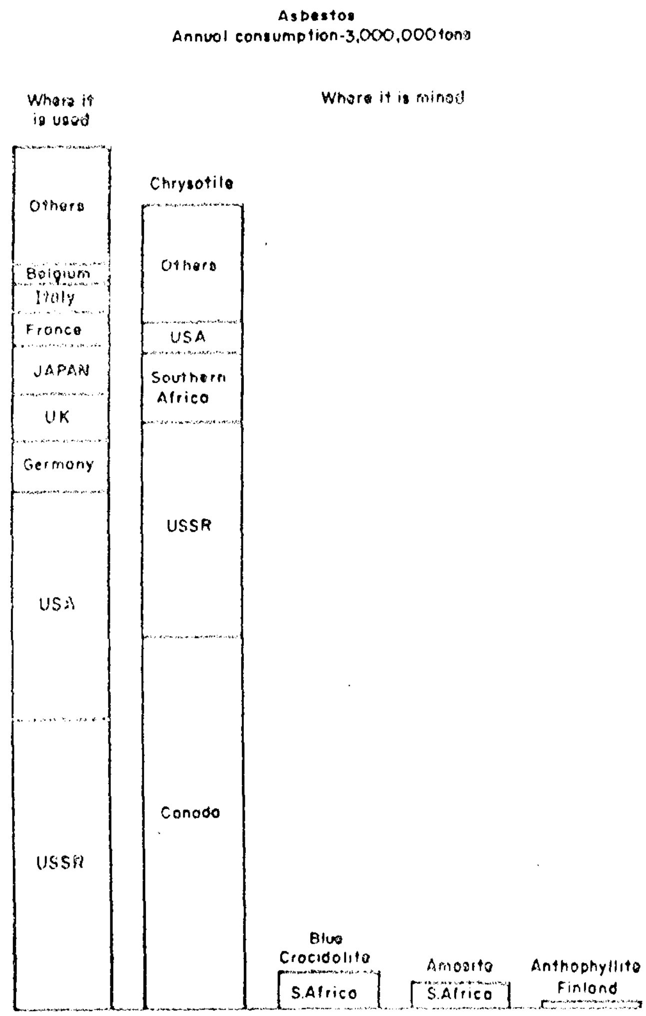

Fig. 2. Areas of use of asbestos.

The different characteristics of asbestos fibres dictate their uses, their applications and their mode of packing and handling. For example, amosite can be pressure packed and palletized, whereas chrysotile lends itself more readily to containerization. By far the greatest use of chrysotile is in the asbestos cement industry. Amosite is used mainly in insulation and building products. Crocidolite, due to its excellent acid resistance, finds its major application in the manufacture of battery boxes in this country. It is added to the pitch mixture in unopened dissoluble bags.

Very broadly it can be said that current friction materials, whether they be disc brake pads, passenger car and commercial vehicle brake linings or clutch facings, contain 50 per cent chrysotile asbestos. The new trends of development, particularly in the fields of disc brake pads and commercial vehicle brake linings, indicate that the percentage of asbestos included in the mix is likely to decline. Some new materials now contain approximately 40 per cent asbestos, and newer mixes can be foreseen with an even lower percentage, probably down to a minimum of 30 per cent. The pads for disc brakes require less asbestos fibre than conventional drum brake linings. It is estimated that more and more passenger cars produced in the U.K. will in future be equipped with disc brakes, particularly on the front wheels.

THE BIOLOGICAL EFFECTS OF ASBESTOS

The variation existing in the biological effects of the different types of asbestos is the subject of considerable interest and research, and the extent to which the physical and chemical characteristics of the asbestos itself influence biological effects is being investigated. The role of trace elements and contaminants associated with the fibres has also to be considered.

The chief biological effects of asbestos are confined to the lung and the pleura, or lining of the lung and chest cavity, and to the peritoneum, or lining of the abdominal cavity. A few cases of skin corns have occured in asbestos workers, but these are becoming much less common.

All types of asbestos, if inhaled in fairly high concentrations over a considerable period of time, may cause fibrosis of the lungs. This disease, called asbestosis, consists of thickening of the lung membranes with resultant stiffening of the tissues and interference with oxygen uptake. The interference with gas transfer is the reason for the shortness of breath which causes the disability associated with asbestosis.

The amount of exposure required to produce fibrosis of the pleura, with or without calcium deposition in the scars, is more debatable. It may be that shorter, less concentrated exposures, particularly in youth, leave this mark upon the pleura. In any event this particular effect of asbestos inhalation causes little or no disability in itself.

Exposure to asbestos may lead to further complications, e.g., heart failure, cancer of the lung, or, rarely, to malignant changes in the pleura or peritoneum, known as mesothelioma. Cancer of the lung has been shown to be more common in asbestos workers who smoke, just as it is in the general population. Mesotheliomas are very uncommon throughout the world, but in some areas they have been associated more frequently with exposure to crocidolite than to chrysotile, amosite or anthophyllite. The reasons for this are at present obscure, but are being sought intensively by investigators in many different countries.

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HYGIENE STANDARDS FOR ASBESTOS*

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AS LONG as there is any airborne asbestos dust in the work environment there may be some small risk to health. Nevertheless exposure up to certain limits can be tolerated for a lifetime without incurring undue risks.

A hygiene standard for asbestos was published in the U.K. by the Ministry of Labour in 1960 and was taken from the annual list of Threshold Limit Values of the American Conference of Governmental Industrial Hygienists (ACGIH) (Committee on Threshold Limits, Annually).

The British Occupational Hygiene Society formed a Hygiene Standards Committee in 1965 to advise on hygiene standards. This Committee recommends the use of the ACGIH list of standards and supplements this with critical examinations of ACGIH and other standards considered unsatisfactory by British workers. The Hygiene Standards Committee has expert Sub-Committees, each of which is concerned with a specific standard. There is a sub-committee on asbestos dust in air, one on trichloroethylene vapour and its urinary metabolites, one on airborne vegetable dusts in the textile industry, another on noise criteria for hearing conservation and two new ones are coming into being; on cadmium oxide fume and silica dusts in air.

It is important to take into account the economic consequences of any recommendations made as well as the benefits to health, and this is one reason why on each of these Hygiene Standards Sub-committees, scientific and medical experts from industry are included. The value of a standard rises in proportion to the number of people who become protected by it. A particular advantage of direct industrial representation on hygiene standards committees is that the industry more readily identifies itself with the standards recommended.

The Hygiene Standards Sub-committee on Asbestos, under the Chairmanship of Professor Lane, has developed new hygiene standards for airborne chrysotile dust (LANE *et al.*, 1968). These were based on the results from a medical and environmental study at an asbestos textile factory in England, in which investigations were made on 290 of the men employed at this factory in the period of 1933–1966.

The Sub-committee considered that the degree and nature of the risk associated with the standards should be specified and the method of the derivation of the standard from the data presented should be described in detail. It was also considered that the standards should give prominence to the gradually increasing risk in relation to the concentration rather than to the single figure threshold concept. Open recognition should be given to the possibility that people might be adversely affected, even

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

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when the recommended standards of air cleanliness are maintained. It was recognised that to protect the hypersusceptible workers environmental control would have to be supplemented with medical examinations.

It was evident from the data made available to the Sub-committee, and from the earlier American experience, that when concentration is held constant the prevalence of asbestosis was highest among those with the greatest duration of exposure. Over a period of time, dust accumulates in the lungs and gives rise to asbestosis. However, some of the dust is removed from the lungs, for example, by being dissolved. Consequently, if it is assumed that none is removed and exposure is limited accordingly, a safety factor is thereby incorporated. The problem of relating prevalence with concentration and with duration of exposure was resolved by assuming that the cumulative amount of asbestos remaining in the lungs from a given exposure is equally dependent on the dust concentration and on the duration of exposure to that concentration.

The asbestos dust concentration had been measured at the textile factory concerned with several different instruments, including the membrane filter method, in which the number of fibres longer than 5 μ was counted. The dust concentration to which different workers had been exposed varied from 1 fibre/cm^3 to 27 fibres/cm^3 over periods from 10 years to 33 years.

The exposure of an individual was expressed as fibre years/cm^3, that is, the product of the average concentration to which he was exposed during working hours and his years of exposure to this average. A curve was developed relating the prevalence of asbestosis to exposure expressed in this way. The principles on which this was based may be explained as follows.

An individual's response to dose of any foreign substance can be expressed by a line (Fig. 1). There is a dose which produces no response whatsoever. This is marked by the threshold A. If the individual is given progressively higher doses, the response progresses correspondingly. The least positive response may be real but merely undesirable. A higher response may have sensory manifestations. A still higher response might be associated with observable physiological changes and overt clinical effects. The highest responses of all would perhaps be signified by loss of consciousness, or even death.

The degree of response may be conceived to be measurable objectively on a continuous scale starting at zero, and the scales of dose and response could be chosen to linearise the relationship between them, as in Fig. 1. The dose–response relationship could then be described by the slope of the line and the point where the line strikes the dose axis. The slope of the line expresses the rapidity with which increases in dose produce increases in response in this individual. The steeper the slope the greater the safety factor necessary in practice to allow for the inevitable occasional excursions of dose above the maximum desirable.

Doses which give zero response are never, in fact, known with absolute certainty since the sensitivity of measurements of response is limited. A response which can just be detected in a man corresponds to another and higher dose, shown as threshold B on Fig. 1. Also, one is not normally considering just one individual. As with all other characteristics of man, the position and slope of a dose–response line varies from one individual to another. Each man's dose-response line is different with a

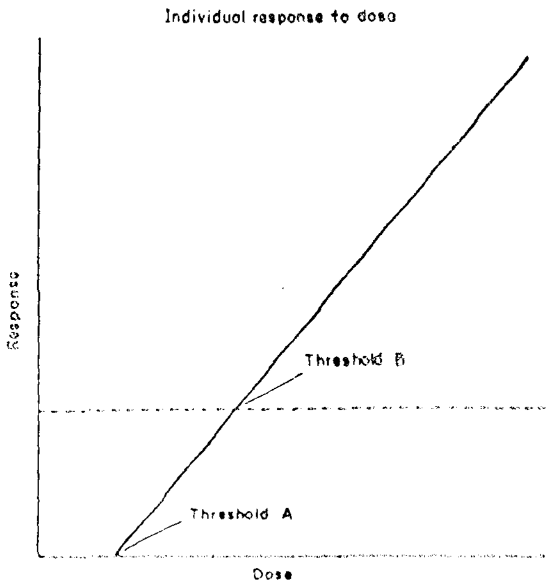

FIG. 1. Individual response to dose.

different threshold dose and a different slope. A particular population under study is represented by a family of dose-response lines centred around the line for the average man.

In a real population the threshold dose will vary from one individual to another about an average value, as in other medical norms. It is to be expected that the size frequency distribution of threshold doses would be a hump-shaped curve tailing away on either side of the central value, as shown in the Fig. 2a.

In a real field study it is established whether a man has or has not been affected. Exactly when or in what concentration he first developed the characteristic response is usually not known. A graph showing exposure against the total number of people affected by it would be a cumulative sigmoid curve, illustrated in Fig. 2b, derived from the size frequency distribution in Fig. 2a. This tails away down to zero response at zero exposure.

An air quality standard is still associated with a small but non-zero probability of men being affected by the contaminant in question. The risk of people being affected can be made as small as one wishes. Zero risk is the ultimate target and an air quality standard has to be a compromise between the costs of bearing a health risk and the costs of air contaminant control.

A curve was fitted to the data from the textile factory on asbestosis, detected clinically and the exposure in fibre years per cm^3 of all the individuals under study over their years of employment up to 1966. The bottom end of the fitted curve is shown in Fig. 3. The three points relate to three of the groups of workers studied. The exposure

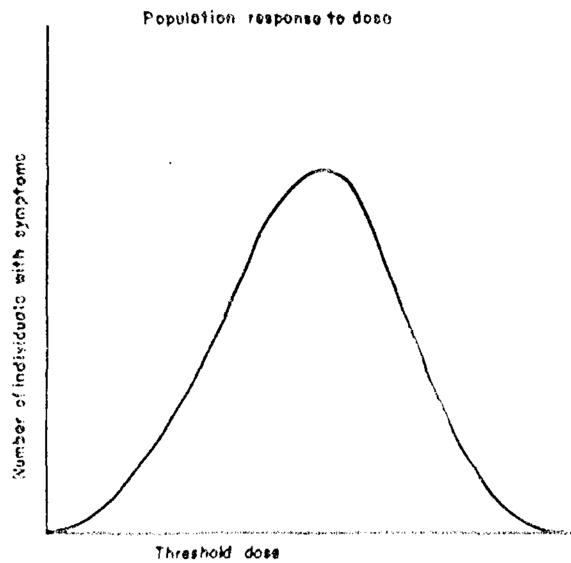

FIG. 2a. Population response to threshold dose.

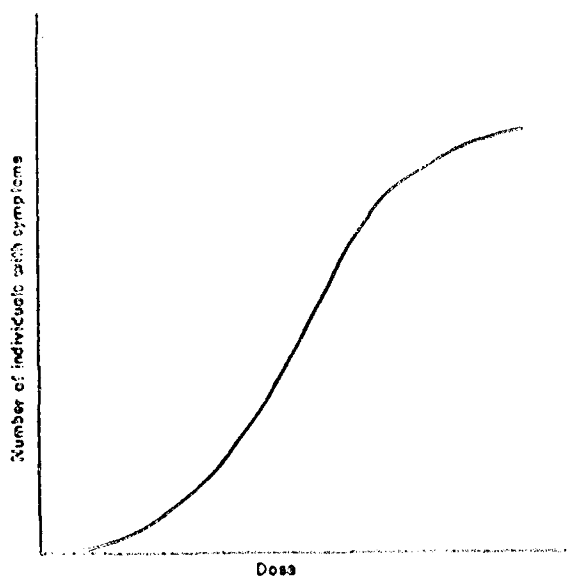

FIG. 2b. Population response to dose.

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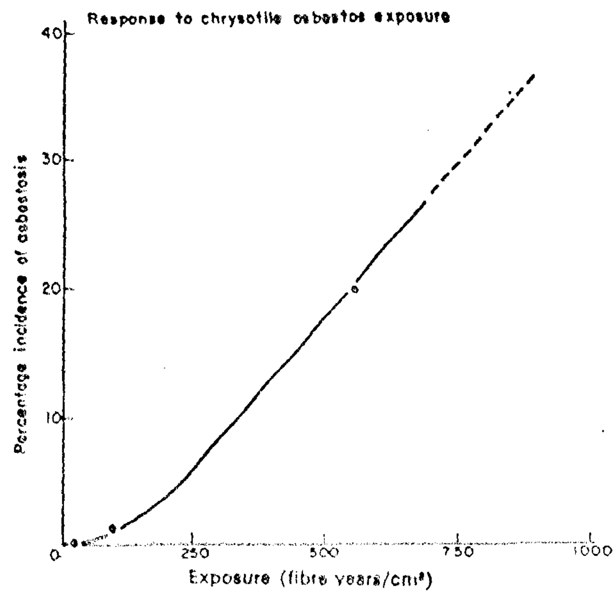

FIG. 3. Response to chrysotile asbestos exposure.

is shown on the horizontal axis, expressed in fibre years per cm³ and the corresponding prevalence is on the vertical axis, showing the proportion of people with crepitant basal rales.

Basal rales is the earliest clinically demonstrable effect on the lung due to asbestos and there is a steadily increasing prevalence of basal rales with increase in dust exposure. Only groups with near zero dust exposure show zero prevalence of basal rales.

A problem arises when it is appreciated that there is no exposure which can be said to be absolutely free of risk. There is no single threshold exposure held in common by everyone. There is, consequently, this gradually increasing risk in relation to exposure. The application of dust control to meet a TLV, an MAC, MAK value, or other similar hygiene standard will limit and control the risk but is unlikely to reduce it to zero. It has to be remembered that asbestos is very widely used and brings real benefits to the community at large. A standard could be made so stringent that the cost of dust control is prohibitive, that the production and use of asbestos ceases to be economic, production and use is discontinued and the associated benefits are lost. The benefits gained by reducing the risk of asbestosis through reducing air contaminant exposure have to be weighed against the possible loss of direct and indirect benefits to the community from the use of the material.

One conclusion from the exposure-response curve fitted to the data was that for an accumulated exposure of 100 fibre years/cm³, it is probable that the risk of being affected to the extent of having early clinical signs will be less than 1 per cent. That is, for example, a concentration of 2 fibres/cm³ for 50 years of such exposure while

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at work, 4 fibres/cm^3 for 25 years, or 10 fibres/cm^3 for 10 years. The British Occupational Hygiene Society Hygiene Standards Sub-committee on Asbestos expressed the view that a proper and reasonable objective would be to reduce exposures to below this level and thereby reduce the risk of contracting asbestosis to less than 1 per cent of those who have a lifetime's exposure to the dust. For such workers, who may possibly work for 50 years, the long term average concentration to which they are exposed would need to be less than 2 fibres/cm^3. For others, who will be exposed to asbestos dust in air for shorter periods, the long term average concentration need not be so low, as long as their exposure will amount to less than 100 fibre years/cm^3.

The possibility was considered that short periods of very high concentration for a few weeks or less might be disproportionately important in determining the risk of asbestosis. However, the evidence for this was not conclusive and the committee were satisfied that the risk can be satisfactorily expressed with respect to an average concentration over 3 months and can safely be kept below 1 per cent by ensuring that a man's accumulated exposure does not rise above 100 fibre years/cm^3.

The exposure measured by making fibre counts on membrane filter samples can be converted into exposure measured with an impinger, the American method, by examining the results of side-by-side comparisons of the two instruments. Such comparisons made by the United States Public Health Service in asbestos textile plants have shown that an accumulated exposure of 100 fibre years/cm^3 corresponds to 15 million particle years/ft^3 by standard impinger methods (AYER, LYNCH and FANNEY, 1965). The present American Threshold Limit Value is a concentration of 5 million particles/ft^3 (mp/ft^3) which, if it persisted, would result in an accumulated exposure of 250 million particle years/ft^3 over 50 years.

These American hygiene standards, called Threshold Limit Values, are a system for summarising published information on air contaminants in a convenient form for the day-to-day practice of industrial hygiene. The present American standard for 8-hr averages is thus 17 times higher than the British standard for 3 monthly averages. However, there is a published intention to revise the American standard in view of recent knowledge.

However, the difference between the American and British standard is not primarily due to conflicting evidence on the adverse affects of asbestos. It is because of a different attitude now adopted over the degree of protection which ought to be given against asbestosis.

The American Threshold Limit Value of 5 mp/ft^3 was recommended by Dreessen and his co-workers in 1938 after studying 541 employees in 4 asbestos textile plants where massive exposures to chrysotile occurred (DRESSEN *et al.*, 1938). Only 3 doubtful cases of pneumoconiosis were found at the time of the study in those exposed to dust concentrations under 5 mp/ft^3, whereas numerous well-marked cases were found above 5 mp/ft^3.

A conference held in 1965 on the biological effects of asbestos called attention to the very real probability that the 5 mp/ft^3 limit recommended by Dreessen is inadequate to give complete working-lifetime protection against all forms of asbestos (SCHALL, 1965). Medical data on which the limits had been based were inadequate; more than half of the asbestos workers studied by Dreessen and his co-workers were under 30 years of age and thus had insufficient exposure time for much asbestosis to

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develop. Of the 105 workers exposed to less than 5 mp/ft³, 82 had worked less than 5 years and only 4 had more than 10 years exposure. Moreover, it was a "point-in-time" study; many of the ill were missing, the dead uncounted, and were not considered in the over-all evaluation of the limit.

The British Hygiene Standards Committee finalised its views in November 1967 after studying the British data, and these views were immediately communicated to the ACGIH TLV committee. In May 1968 the ACGIH (Committee on Threshold Limits, 1968) proposed changes to its hygiene standard. The new asbestos limit, while taking into account the British views, had to be based on American experience and considerations applicable to the American industrial scene. Recent evaluation of the health experience in asbestos plants in the U.S.A. had, nevertheless, indicated that the 5 mp/ft³ limit was not sufficiently low to protect workers exposed for 30 years, a period rarely exceeded in America.

In accordance with these findings, the 5 mp/ft³ limit was made a ceiling value below which all concentrations should fluctuate. This corresponds to a time-weighted average concentration over a shift of 2 mp/ft³. Since the count by Impinger procedure often consists primarily of extraneous particulates, an alternative fibre count was recommended, using the membrane filter method in which fibres greater than 5 μ in length are counted as in Britain. On this basis, for a time-weighted 8-hr average limit by Impinger count of 2 mp/ft³, the corresponding limit based on the fibre count is 12 fibres/cm³. This limit is intended to reduce to an insignificant risk, the occurrence of asbestos disease among those exposed for 30 years to all forms of asbestos.

The intended changes in American TLVs give two years' notice and objections to them should be conveyed to the TLV committee of the ACGIH. All objections are given the most serious and sympathetic consideration and users are strongly advised to take advantage of this if they have reason to question the proposed changes.

The standards of the British Occupational Hygiene Society recommend that a person's accumulated exposure to chrysotile asbestos should not exceed 100 fibre years/cm³. It is probable that the risk of being affected to the extent of having early clinical signs of asbestosis will be less than 1 per cent if the conditions comply with these standards. It is believed that this is the first time a hygiene standard has been associated with such a specified degree of protection.

The standards refer essentially to an average concentration during working hours over 3 months of 2 fibres/cm³. In an environment where this 3 monthly average just equals 2 fibres/cm³, the concentration within this period will sometimes be above this value and sometimes below. The maximum 8-hr average will thus be somewhat higher than 2 fibres/cm³. The proposed change in the American TLV is to a maximum 12 fibres/cm³ 8-hr average, which if exceeded on a shift demonstrates non-compliance. Thus, there may be a rough degree of consistency between the hygiene standards from the two countries' organisations, so far as this is possible. The Factory Inspectorate in their work have often only a short time during a day to come to a judgment on conditions and are considering a development of this, applying a maximum for even shorter periods, of a few minutes, which if exceeded would indicate a probability that the Asbestos Regulations are not being complied with.

There is a growing body of information on chrysotile dust and other asbestos dusts from many countries, and it is hoped that in future the views from different

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parts of the World will be sought so that standards for testing air cleanliness can, as far as possible, be held in common. Even so, the risks that may be tolerated can vary from country to country and from one situation to another within a country.

The air quality attained in industry in different countries does differ and, no doubt, will continue to differ. A wealthy country can afford to spend more money on air-contaminant control. Also, a country very conscious of the slightest risks to which its workers may be exposed through their occupation may be expected to have different standards from one which is not, where other health risks may be so much the greater.

The benefits to the community from the use of inexpensive asbestos products have in some measure to be weighed in the balance against the benefits to the health of the workers that would accrue by reducing asbestos dust exposure.

The British Occupational Hygiene Society Sub-committee on Hygiene Standards for Asbestos has not yet decided whether their chrysotile standards would be suitable for amosite or crocidolite dust, nor whether they give sufficient protection against lung cancer or mesotheliomas. The ACGIH, on the other hand, make no distinction between different types of asbestos in their standards. In this country it should be remembered that the Senior Medical Inspectors' Advisory Panel on Problems arising from the use of Asbestos considered that the evidence to date on balance indicated that a particular significance must be given to crocidolite as a cause of mesotheliomas (Ministry of Labour, 1967). That Panel recommended 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. Whatever measures may be adopted to control asbestos dust, the Panel urged that these be even more rigidly applied to crocidolite. The Factory Inspectorate is also developing procedures for testing hygiene standards in factories and is seriously considering the adoption of especially rigid requirements where crocidolite is used.

To derive hygiene standards for an air contaminant which provide a known degree of protection against a health hazard, it is necessary to have a body of data showing the amount of air contaminant to which people are exposed and the corresponding effects or lack of them in the people. It is also necessary to have a grasp of the consequences to industry and users of limiting and controlling emissions of the contaminant. Our present information is very imprecise, particularly in terms of the practical consequences of specific hygiene standards. In developing recommendations for a hygiene standard, the British Occupational Hygiene Society Sub-committee found that knowledge of the relationship between exposure and risk was not the greatest area of uncertainty. A much more difficult and contentious problem was to decide on what, in fact, was an acceptable level of dust control.

More information is needed, for example, on the expense of dust control. Where this is done by ventilation it is important to know what is the minimum amount and what kind of local exhaust ventilation and dilution ventilation is necessary to achieve a given degree of air cleanliness in a work place, since costs tend to climb as the cube of the air flow.

Research is needed to determine the balance between local and general ventilation which produces a specified degree of control at minimum cost. By setting down the capital cost, installation cost, running and maintenance costs, it becomes possible to grasp more firmly the consequences of adopting particular hygiene standards. This kind of information is needed throughout the field of asbestos dust control so as to be able to weigh up the costs of achieving high air cleanliness.

This does not reduce the choice of an air quality standard to a mathematical equation, nor does it avoid the need to exercise wise judgment in the choice of standard. However, the judgment can become a little less arbitrary than at present.

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EXPOSURE TO ASBESTOS DURING BRAKE MAINTENANCE*

D. E. HICKISH and K. L. KNIGHT

Medical Services, Ford of Britain, Brentwood, Essex

EXPOSURE DURING CAR SERVICING

THERE is little maintenance of passenger vehicle brakes involved at the manufacturers' premises, and therefore an investigation was carried out at the Service Bay of a Ford Main Dealer in the Greater London area. This Dealer normally services 10–20 cars per day, but blowing-out of brake shoes and drums is not included in all routine services. It is the blowing-out procedure which is the subject of the study.

Air sampling was carried out using membrane filters, the sampling and subsequent assessment being in accordance with the technique described in the *Hygiene Standard for Chrysotile Asbestos Dust*, published by the British Occupational Hygiene Society (1968).

Static samples were taken by the side of the car (Fig. 1) and composite samples were also taken in the dust-cloud during the blowing-out procedure, continuing by the side of the car for the remainder of the sampling period. Normally the mechanic takes care to blow the dust away from himself, so this sampling procedure should over-estimate exposure. Two sampling periods of 45 minutes were used, and during the first period one Cortina Estate and one Anglia Van received brake blow-outs, and during the second period one Cortina car was dealt with. The results are shown in Table 1.

TABLE 1. ATMOSPHERE SAMPLES DURING CAR BRAKE SERVICE

Location of samples		Fibres/cm^3	
	1st period	2nd period	Time-weighted average
By car	1·12	1·42	1·25
Dust cloud then by car	1·71	3·62	2·55

An estimate of the daily exposure of the mechanic engaged on brake cleaning was obtained by a series of personal samples (Fig. 2), covering an entire workshift, during which brake servicing was carried out on 11 vehicles. The results are shown in Table 2.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

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Table 2. Personal samples during car brake service

Sample	Concentration (fibres/cm³)
1	0·63
2	1·12
3	0·21
4	0·96
5	0·38
6	0·79
Time-weighted average	0·68

EXPOSURE DURING TRUCK SERVICING

Maintenance of truck brakes involves a somewhat different type of operator exposure as the servicing is more complex, and therefore the number of vehicles dealt with is less. The larger size of wheels and drums, on the other hand, makes it difficult for the operator to avoid the dust cloud produced, and personal exposure could be higher than that during car maintenance. Further sampling was therefore carried out in a large fleet workshop with equipment similar to that used for the passenger car tests.

Static samples, each of approximately 3 hr duration, were collected during the morning and afternoon periods at three positions; at the bay adjacent to the one at which brake cleaning was carried out, at the next bay, and in the centre of the garage.

Brakes were blown out during the morning, but not during the afternoon. The results are given in Table 3.

Table 3. General atmosphere samples during truck brake service

Location of sample		Concentration (fibres/cm³)
Adjacent bay	Morning	0·28
	Afternoon	0·07
2 Bays away	Morning	0·17
	Afternoon	0·07
Centre of garage	Morning	0·49
	Afternoon	0·11

Personal samples were obtained from two men—the man engaged on brake cleaning, and the man engaged on clutch repair work at the adjacent bay. The first period of 1·5–2 hr included the period of brake cleaning, and the second period of approximately 5 hr represented the remainder of the shift. The results are shown in Table 4.

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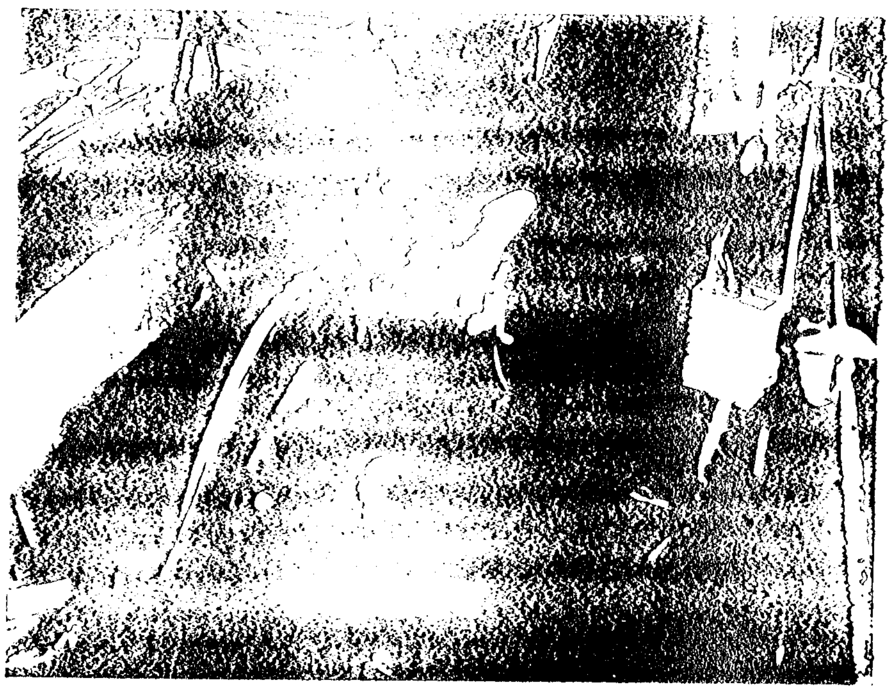

FIG. 1. Static sampler by side of car.

(facing p. 18)

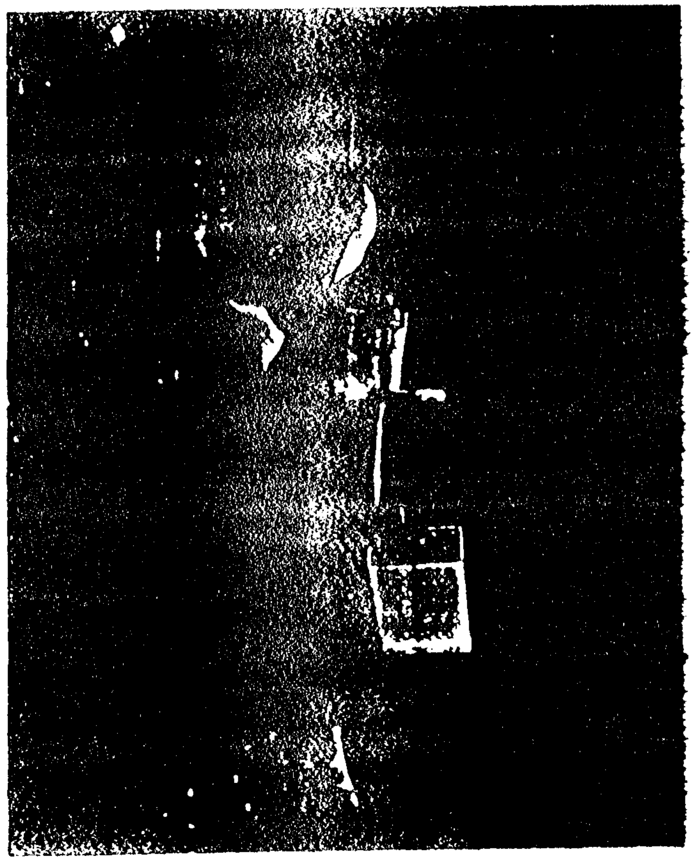

FIG. 2. Personal sampler.

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TABLE 4. PERSONAL SAMPLES—TRUCK BRAKE SERVICE

Operator	Concentration (fibres/cm³)
Brake cleaner	
during cleaning	7·09
after cleaning	0·08
Time-weighted average	1·75
Clutch repair—adjacent bay	
during cleaning	2·25
after cleaning	0·11
Time-weighted average	0·79

SIGNIFICANCE OF EXPOSURE LEVELS

The Hygiene Standard suggests that exposure should not exceed an accumulated level of 100 fibre-years/cm³. On this basis, a man exposed for the whole of his working lifetime of 50 years, should not be exposed to concentrations exceeding 2 fibres/cm³. While an exposure to asbestos of this length is somewhat improbable in the case of motor mechanics, nevertheless the results have been interpreted against this value, and the findings are summarized as follows:

Car servicing

While the standard may be exceeded in the dust cloud during actual brake cleaning, the personal exposure of the operator studied was well below the standard.

Truck servicing

The standard is not exceeded during brake cleaning in the general atmosphere away from the immediate vicinity of the operation, but personal exposures in the vicinity do exceed the standard. On a daily basis, the personal exposure levels are below the standard, although that of the brake cleaner approaches it.

It should be noted, however, that in a fleet workshop, brake cleaning operations do not necessarily take place daily.

THE NATURE OF AIR-BORNE DUST

Brake lining materials contain 40–60 per cent of asbestos, and it was somewhat surprising to find that particles of a fibrous nature were scarce in the air samples collected. In a laboratory investigation, specimens of dust were obtained by filing brake lining material, and after sieving through a 200-mesh sieve, these were examined microscopically before and after incineration. Samples of dust were collected from brake drums during car servicing and examined in similar manner.

The results of the examination were expressed as the percentage of particles which were fibrous in nature, and are compared in Table 5, together with a result from an incinerated thermal precipitator sample obtained during brake cleaning.

Table 5. Assessment of fibrous fractions of dust samples

Sample	Percentage of particles seen to be fibrous: Sample not incinerated	Percentage of particles seen to be fibrous: Sample incinerated
Brake lining material	28	12·3
Brake drum dust	0·6	1·6
Air-borne dust	—	1·3

It is clearly shown that the percentage of fibres in the drum dust and airborne dust is much lower than that in the dust formed from the original lining material.

Samples of drum dust were examined by Dr S. Holmes, and his tests showed that chrysotile was present only in trace quantities, or at most at 1 per cent, compared with the original lining content of 40–60 per cent. These findings suggest that there is a change in the physical and/or chemical form of the asbestos during its use as a brake material.

Enquiries were made of research workers in the UK and USA as to whether they had observed a similar effect. Lynch (1968) reported that tests on brake testing dynamometers had shown the presence of few or no fibres in the dust produced from bus and automobile brakes, except under severe braking conditions. In the latter instance, the brake temperature reached 320–370°C, compared with the design maximum temperature of 290–320°C, and it appeared that, under these conditions, the binder decomposed and released part of the asbestos as free fibre. At lower bulk lining temperatures within the normal operating range, the binder behind the surface remains intact. However, the spot temperature at the point of contact between the lining and the drum may be higher than the decomposition temperature of asbestos. The decomposition product, therefore, includes not free asbestos fibres but a different mineral, resulting from thermal metamorphosis.

Holmes (1967) in reporting the analyses described earlier in this paper, commented that the normal thermal decomposition product of chrysotile is forsterite, a non-fibrous crystalline magnesium silicate. However, our samples of brake drum dust contained very little forsterite, but rather were mainly comprised of an amorphous magnesium silicate, which is non-fibrous. Little was known at that time about the structure and composition of this substance. Whilst there was no evidence to suggest that the material was a health hazard, this possibility could not be dismissed, and animal experimentation has been commenced in the U.S.A.

CONCLUSIONS

Our investigations show that exposure to asbestos during brake maintenance is not as severe as was anticipated, and in the situations we examined, the personal exposure of the operators was below the limit corresponding to 50-year exposure.

It is however recommended that care should be exercised during brake cleaning to avoid inhalation of the dust produced, and the development of cleaning procedures which would reduce air contamination is desirable. The present trend towards the introduction of "flow-line" servicing at Dealers works, in which one individual may be engaged almost entirely on brake servicing, emphasises this point.

Our environmental studies have not included maintenance procedures which involve the filing or grinding of brake lining material, and we would envisage that these would give rise to considerably increased air contamination by chrysotile asbestos, with the attendant need for strict precautions to prevent the inhalation of fibres.

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TECHNICAL IMPLEMENTATION OF THE NEW ASBESTOS REGULATIONS*

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THE NEW Asbestos Regulations were signed by the First Secretary of State on May 13 1969, and will therefore come into operation on May 14 1970. They are based on the concept that asbestos dust must be so controlled as to be at a level which will not be liable to cause injury to health.

For the purposes of our discussion today, I believe we should take this to be a level of 2 fibres/cm^3 and 0·1 mg/m^3 for chrysotile asbestos. A fibre is taken as being 5 μ or over in length with an aspect ratio of at least 3:1. This is of course the standard proposed by the British Occupational Hygiene Society (1968) and is based on time-weighed average concentrations. There is a practical limit on the time over which samples can be taken if the exercise is not to become unnecessarily cumbersome and expensive. On this basis, a sample of 4 hr duration seems a reasonable compromise. If we accept this, as a practical sampling time then the overall standard becomes 2 fibres/cm^3 over this four hour sampling period.

We cannot, however, afford to ignore entirely peak concentrations which will occur during this period, and it seems reasonable to expect that a concentration of say 12 fibres/cm^3 should not be exceeded during any period of 10 min, i.e. we might regard 12 fibres/cm^3 as a ceiling value.

It must be remembered that we are using the fibre count not as an absolute measure of concentration but rather as a conveniently measurable parameter to indicate the total asbestos in the air. The work leading to the formulation of the BOHS Standard referred to above related to conditions in the textile industry and not enough information is yet available on the relationship between mass of asbestos and fibre counts in other industries. To further complicate the problem, it is not known what fibre sizes are biologically active and, even if this were known, appropriate elutriation (i.e. the rejection of material not biologically active) would be very difficult with a fibrous material such as asbestos. We, ourselves, are making both fibre counts and total mass determinations by X-ray diffraction analysis in industries, such as the motor industry, where degradation of the fibres may occur, resulting in a substantial change in size distribution.

HICKISH and KNIGHT (1969) have described conditions during the servicing of braking systems. The figures they have quoted are, to a large extent, reassuring in

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

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that they indicate that the levels likely to be found in many sections of the industry engaged in this work are below the level of 2 fibres/cm^3, which is considered, in the light of past knowledge, a safe one for chrysotile asbestos. Their highest figures for the time-weighted average concentration over 4 hr, however, clearly show that over a period of 10 min we may have concentrations exceeding substantially the level of 12 fibres which are quoted above.

I was interested to hear of the increasing tendency to carry out brake overhauls on a production line basis. This, clearly, must increase the exposure of particular individual workers, making the development of adequate precautionary measures even more important and, in this connection, I hope the devices which will be described later to-day can be improved and developed to the point where they become universally acceptable to the operator. Certainly we should not be blowing out brake dust, even if it contains only a few per cent of asbestos.

In regard to this latter statement, perhaps I should say that work at our Industrial Hygiene laboratory confirms the figures indicated in the previous paper. We have found that samples of dust from brake drums, when subjected to X-ray diffraction analysis, contained between 1 per cent and 3 per cent of chrysotile asbestos although the original lining material contained more than 40 per cent asbestos. There seems little doubt that this is due to the considerable thermal degradation which occurs consequent on the high temperatures generated by friction at the interface between the lining and the drum.

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POSSIBLE ALTERNATIVES TO ASBESTOS AS A FRICTION MATERIAL*

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INTRODUCTION

I HAVE been asked to talk on the possible alternatives to asbestos as a friction material. The facts are that if by "alternative" we mean a new or better fibre which might shortly be available as a replacement for asbestos in conventional friction materials, then I think the chances are so remote as to be not worth considering.

This is not to say that if the world supplies of asbestos dried up we would not eventually find a substitute, but it could well be at the expense of a considerable loss in performance, and also at a considerable increase in cost.

THE ROLE OF ASBESTOS IN FRICTION LININGS

Having started on what may appear to be a rather depressing note, let us examine the reasons why asbestos occupies the role of an almost universal constituent in friction materials at the present time.

The first automotive friction linings were made from cotton textile material impregnated with drying oils which were subsequently cured to form a strip of material which, while being flexible and conformable, still exhibited great mechanical strength. The main function of the drying oil was to protect the cotton from attack by atmospheric oxygen, which, even at the temperatures reached by early brakes, would have resulted in the cotton burning had its surface been exposed. A second function of the drying oil was to prevent the cotton from fraying under the influence of mechanical abrasion.

As brake operating temperatures increased, it was found that cotton started to degrade and lose its strength even though still protected from attack by oxygen. In other words, it suffered thermal degradation instead of oxidative degradation.

Around 1910, a technological break-through was achieved when it was discovered that textiles could be woven from asbestos and used to replace cotton, because asbestos neither burns nor loses its strength below about 500°C. However, as brake operating conditions became steadily more severe, a point was reached in about the middle 1940's when, despite the continual improvement of synthetic resins with which the asbestos textile was impregnated, further heat resistance was required, this time because the organic part of the composite was proving inadequate. The solution proved to be to mould brake linings from powdered resins, using short fibre unwoven

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

asbestos to maintain the necessary strength and flexibility. This made possible the inclusion of heavy loadings of mineral and metal fillers which imparted greater heat resistance than could be obtained from resin and asbestos alone, and did so at the expense of a reduction in asbestos content. The last point is important in the context of asbestos substitutes. The question is often asked, "why can't asbestos be replaced by something like glass fibre which, after all, must surely impart sufficient strength?" The answer is possibly "it can", if merely the performance of a textile lining is required, but at the temperatures commonly met in modern brakes, the glass fibre melts even in depth below the operating surface.

Furthermore, as a result of the embrittling effect of mineral and other fillers needed in today's brake lining, glass fibre is inadequate in imparting the necessary strength and flexibility. The same can be said to a greater extent, of the various types of rock wools and mineral fibres which have appeared on the market over recent years. It is interesting to note that not only is the ultimate strength of asbestos almost three times that of glass fibre, i.e. 550,000 lb/in.^{2} but the modulus of rigidity is up to ten times as high, at a value of 30,000,000 lb/in.^{2}. Typical figures for other materials are say 100,000 lb/in.^{2}, for steel wool and down at 60,000 lb/in.^{2} for mineral wool.

The current situation therefore, is that in drum brake linings of normal configuration used for passenger cars and commercial vehicles, there exists no substitute for asbestos which would not result in a deterioration of performance and strength.

DISC BRAKE PADS

Rates of energy dissipation continue to rise and we have now passed the point where moulded drum brake linings are adequate for a large percentage of passenger cars. In this country, nearly 50 per cent of the passenger car axles are equipped with disc brakes, and for the second time in nearly half a century, there seem to be technical possibilities of reducing the asbestos content of friction materials. It is purely fortuitous that the friction materials used in disc brakes are designed to a stronger shape, that is, more or less square or circular pads of considerable thickness, supported, furthermore, by a metal plate of adequate stiffness. The friction material, therefore, does not have to stand up to handling during assembly, does not have to withstand riveting, and could, from the point of view of bulk mechanical strength alone, be made without a high loading of fibrous reinforcement of any kind. There remains, however, thermal shrinkage and thermal shock, and in order to prevent the formation of tensile cracks normal to the operating surface, a percentage of asbestos fibre is still retained. Nevertheless, it cannot be said that the use of asbestos in disc brake pads remains a technical necessity, and it is in this field of friction materials that some departure from resin-asbestos based composites could occur in the next few years on technical and performance grounds.

FRICTION MATERIALS FOR CLUTCHES

As yet, I have confined my comments to brakes, but the development of friction materials for clutches has followed broadly similar lines. In recent years, however, we have seen the start of a growing replacement of manual clutches by automatic transmissions where the clutch packs are immersed in oil and therefore do not give rise to airborne contamination. The friction materials used are, in any case, made from sintered metals or paper based facings in which the fibre is largely cellulose. This feature is made possible by the low operating temperatures, due in turn, to the fact that the materials are immersed in oil.

Clutches for heavy duty manual shift gear boxes are, in the U.S.A., being superseded at a significant rate by the spider clutch. This is a type of clutch in which the friction material, instead of being in the form of a thin annulus, consists of a number of buttons rather like disc brake pads, and these again could be made from asbestos-free material such as sintered metals or cermets (ceramic-metallic compositions).

Summarizing the situation at the present time therefore, it can be seen that there is a drift towards the use of smaller quantities of asbestos in friction materials as a result of a number of purely performance considerations and design changes, that is, reduced amounts of asbestos in some disc brakes, and replacement by other materials in automatic transmissions and some dry clutches.

OTHER FACTORS AFFECTING EXPOSURE TO ASBESTOS

There are, however, several other factors which enter the equation when considering the exposure to asbestos during brake and clutch maintenance, which is the subject of this meeting.

The first is that the durability of friction materials is increasing, as is the temperature at which they will operate satisfactorily. I mention these facts not only because they tend to offset the adverse effect of increase in vehicle miles per year, but because they affect the whole chemistry of asbestos in friction materials. The second important point is that the type of asbestos used in friction materials is chrysotile or white asbestos, and is different from blue asbestos or crocidolite, not only in colour, but in chemical composition and also in chemical decomposition. The third important point is that under the influence of heat alone, chrysotile asbestos decomposes by loss of water of crystallization at a temperature of around 600°C. The process is rather slow, taking well over an hour to convert 50 per cent of the asbestos to its degradation products. These form a series of iron magnesium silicate materials known as olivine, the end member of which is forsterite. The olivine series of minerals are quite unlike asbestos, both physically and chemically, being non-fibrous, and in fact, widely occurring as the major part of many common rocks (basic and ultramafic igneous). One would not expect that a significant amount of asbestos would be converted to olivine during braking except under conditions of very severe duty such as a fade test, but in fact it is exceedingly difficult to detect asbestos in friction material wear products. It has only on rare occasions been possible to detect asbestos in wear products by X-ray diffraction methods, and one has to resort to electron diffraction, selecting occasional individual small fibres to show its existence. This rather surprising fact has been known for several years and current theory suggests that it is accounted for by very high temperatures which are said to exist at the points of real contact between the lining and drum or disc, even at bulk temperatures as low as 100°C.

Whether this explanation is correct or not, it remains a fact that very little asbestos survives in the wear products after brakes or clutches have been used under normal

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operating conditions. As the durability of brakes improves, further reductions will occur in the percentage of asbestos which survives the wear process, because each particle of asbestos is then subjected to more heat treatment. Of the approximately 1 per cent of asbestos remaining in wear products, a large proportion is ground down during the wear process to much less than the 5 μ length at which particles are judged to be fibres. This is easy to understand when one considers that under normal conditions a lining will lose about one-millionth of an inch of thickness for every 20 ft of sliding.

Over recent weeks I have had regular tests performed in which employees' private cars, and trucks from the Company fleet have been brought into the garage for brake cleaning. The drums have been removed and in a garage with no forced ventilation, all loose dust has been removed from the drums and back plates by the use of a compressed air jet. As each brake was cleaned, instantaneous atmospheric samples were rapidly taken by a hand-pump from the centre of the dust cloud. Several of the dust clouds were visibly filthy, and would, in my view, be avoided by the operator; the dust counts taken at the point of maximum dust density were as given in Table 1.

TABLE 1. DUST COUNTS DURING BRAKE CLEANING BY COMPRESSED AIR-JET

Test No.	Non-fibrous above 2 μ	Fibre count 2–5 μ	Fibre count Above 5 μ
Samples			
1	2000+	306	5·4
2	109	11	2·1
3	402	17	2·5
4	607	21	3·7
5	475	37	5·3
6	1513	49	8·2
7	628	35	3·2
10 min average	181	5·0	0·8

The interesting points from this exercise are, firstly, the ratio of the number of particles of asbestos to the total dust particles of a similar size, showing a very small percentage of asbestos, and, secondly, the distribution of size of the fibrous element, suggesting that those particles over 5 μ must have been only just over.

I am not suggesting for a minute that the practice of blowing out brake drums with a compressed air line is to be recommended, merely that an intense dust cloud of this composition is a lot less harmful than one might think.

Unfortunately, at the present time, no corresponding data is available from clutches but one would expect the situation to be better than in brakes rather than worse, because on the one hand, surface rubbing speeds are higher, giving rise to higher point contact temperatures, and on the other hand, wear rates are very much lower resulting in an even finer subdivision in the wear products.

POSSIBLE ALTERNATIVES TO ASBESTOS

I have confined my comments to an account of changes which are taking place in friction materials at the present time in the normal course of technical development, in the belief that, although the use of raw asbestos must be tightly controlled, the wear products from friction materials are probably no more dangerous to health than many other dusts and can be treated as "merely dirty". If further evidence comes to hand to suggest that a substitute for asbestos must be found, then under the pressure of necessity, a list of possible replacements could be drawn up as follows:—

Glass fibre	Low strength—low melting point—severe frictional instability.
Steel wool	Low availability—high cost—low strength—damage to drums.
Mineral wool	Very low strength—brittle to the extent of limiting mixing processes.
Carbon fibres	£100/lb currently forecast to fall to £1/lb in several years' time. Still ten times too expensive.
Sintered metals and cermets	Probably the best possibility eventually, but cost will always be relatively high.

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CONTROL OF THE USE OF ASBESTOS-CONTAINING FRICTION MATERIALS*

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INTRODUCTION

THIS paper outlines the measures taken by the asbestos-using industry to find out the nature and causes of asbestosis, and the work it has carried out on environmental control. Particular reference is made to dust created during the manufacture and subsequent handling and machining operations of friction materials containing asbestos.

It is rather less than 40 years ago that the need for control of asbestos dust in large quantities was first recognised and the Government Regulations which became law in 1933 have resulted in a considerable improvement in the health record of people employed in asbestos factories.

In the 1950's, however, it became apparent that although the improvement had been dramatic, cases of asbestosis were occurring in people who had joined the industry since the dust control measures were introduced and it was also apparent that certain users of asbestos products, such as thermal insulation engineers or laggers were also being affected.

As a result of this the three leading Companies in the asbestos industry, B.B.A. Group, Cape Asbestos and Turner & Newall, decided that further investigation into the nature and causes of asbestosis was necessary and they financed and set up the Asbestosis Research Council with this objective. Since then the Asbestosis Research Council (ARC) has continuously sponsored research at Cambridge, Reading and other centres and has co-ordinated the work of its own research, medical and engineering teams concerned with this problem.

Much of the increased awareness of health problems connected with asbestos stems from these research projects and the industry's own experts are acknowledged, and have been consulted regularly, by Government Departments and other organisations both in this country and overseas. The ARC has drawn up some Codes of Practice on the handling of asbestos in those areas where the control of asbestos dust was thought advisable at that time. The ARC has also played an active part in the formulation of the new Asbestos Regulations which are expected to become law in about 12 months.

Because of its considerable experience in using asbestos and asbestos products itself and its concern that these products should be used without risk, it set up an additional committee last year with the principal object of intensifying the study of problems arising in the working environment, dealing with those areas where it had only

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

recently become apparent that some control might be necessary and helping those concerned with satisfying the requirements of the new regulations.

This Committee is the Environmental Control Committee of the Asbestosis Research Council and it consists of a number of working groups concentrating on the special problems of particular areas. One of these Working Groups is being devoted to the field of friction materials, and has, as its constituent members, Small & Parkes (makers of Don materials), Ferodo and Mintex. This Group, which has been formed recently, is concerned with the users of friction materials, both at its major customers —the brake, clutch and car manufacturers—and also in the replacement and service field.

Its concern has been, first of all, to establish whether or not a problem exists and, if so, how big a problem it is. To this end dust counts have been taken both in premises where friction materials are handled and serviced, and at customers' premises, by the three Companies principally involved. These tests have been taken by their own dust counting teams who have many years' experience in accurate dust measurement. This work is continuing and a picture is being built up of dust counts likely to be encountered whilst carrying out typical operations during brake and clutch maintenance. Analysis of the dust found in brake drums is being carried out also to determine whether all the fibrous dust is asbestos or not.

In addition to gathering and collating information on a large number of dust readings in various types of service premises, the Working Group is preparing two codes of practice for users of asbestos-based friction materials which will be issued by the Asbestosis Research Council. One of these is for the guidance of bulk users in factory premises carrying out, in some cases, operations similar to those carried out in our own factories, such as drilling and grinding, and the other is for the guidance of those engaged in servicing of brakes and clutches.

The purpose of these Codes of Practice or Notes for Guidance will be to remind users of the principal requirements of the new Asbestos Regulations to recommend the action that they should take to meet their requirements. The aim is to achieve what is, after all, the whole purpose of the Asbestos Regulations and the Asbestosis Research Council's work—to reduce concentrations of asbestos dust to a safe level. The long experience of the manufacturers of friction materials in dust control over a wide variety of operations will enable them to recommend measures and types of equipment to help the users to comply with the Regulations and protect the health of their employees.

A further line of study is being followed to see whether a satisfactory surface-sealing agent can be found in order to cut down the amount of dust given off in handling a new lining, even though this amount is already small.

It is not possible for us to take dust counts in every service garage in the country and the work of the Friction Materials Group has been directed to dealing with, and giving advice on, situations which are likely to be typical of those found in service garages. It is, however, the intention to give as much help and advice as possible with the facilities that are available and requests for help or advice directed to the Asbestosis Research Council will be passed on to the Working Group for action.

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REMOVING DUSTS FROM BRAKE ASSEMBLIES DURING VEHICLE SERVICING—ALTERNATIVE CLEANING METHODS*

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PRELIMINARY CONSIDERATIONS

WHATEVER the criticisms may be from an occupational health point of view, few would deny that the operation of removing brake dusts with an air line is efficient in that the total time to perform the task is extremely short. The time required to perform an operation is of vital importance in industry and any process changes will always be judged relative to the time scale. In addition, the effort required from an operative in using the method should be minimal and it is easy to see that the chances of developing a technique of cleaning which will reduce dust emissions but at the same time require no more time and effort are extremely slim. Quite clearly, we must concede from the very beginning that some increase in time and effort involved is inevitable.

When viewed under normal lighting conditions, the result of applying a compressed-air line to remove brake dusts is very dramatic. Unfortunately, mere dramatisation alone is not adequate to describe the emission of dust from a process; more objective methods are needed. The conventional method of evaluating an environmental condition is the measurement of the appropriate parameter (in this case—fibre counts), referring the results to hygiene standards. In experimental work to evaluate dust control methods, simpler, "relative" techniques of measurement have considerable advantages and part of this work is concerned with applying a fairly simple method to define certain environmental conditions which prevail when brake dusts are removed by blowing out with a compressed air line and comparing these with the conditions obtained when a dust control technique is applied. Because the method is a relative one, care to prevent errors from extraneous sources of variation is important. These sources of error are discussed later.

METHODS USED TO EXAMINE ENVIRONMENTAL CONDITIONS

When dusts are released in relatively small quantities it is often impossible to see the clouds under normal lighting conditions. They can be made visible using the Tyndall Beam effect and this has been employed extensively during the experimental work.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

Mass concentrations of airborne brake dusts were determined at two positions by sampling through tared membrane filters. In the first position, a static sampler was placed close to the sources of dust emission. Generally, this sampling position was chosen to be in the area where the results of Tyndall Beam examinations had indicated that the highest dust concentrations were likely to be obtained. Secondly, a personal air sampling device was worn by the operative in such a manner that the sampling head was attached to the wearer's lapel, as near as practicable to the breathing zone.

Samples for particle counting were taken, again in the operative's breathing zone, using a Konimeter, and membrane filter samples were also taken for subsequent fibre counts by microscopy, using the method described by ADDINGLEY (1966). Possible weighing errors due to static charges on membrane filters were prevented by weighing in a field of ionising radiation, as described by HIGGINS and DEWELL.

The results of fibre counts showed that the numbers of fibres present in the high total dust concentrations obtained when an air line was used were of a low order of magnitude and hence the total dust concentration was used as a relative method to describe the dustiness of the environment.

The location selected for the experiments was in a workshop area, behind a glazed partition, and well away from access doors, so that comparisons of cleaning methods were not affected by variations in local air movement. Smoke tests were carried out at each sample period to confirm this point.

CONDITIONS OBTAINED WHEN A COMPRESSED AIR LINE WAS USED TO REMOVE BRAKE DUSTS

A commercial vehicle brake assembly, after removal of the brake drum preparatory to cleaning, is shown in Fig. 1. In this particular case, the hub had also been removed for bearing replacement which facilitated cleaning operations. It should be noted that this is not always so and for the majority of our tests the inconvenience of the hub being present had to be contended with.

A series of Konimeter samples were taken during typical operations and also after the process had ceased. The counts for these samples are summarized in Table 1.

TABLE 1. RESULTS OF KONIMETER SAMPLES DURING BLOW-OFF

Sample	Number of brake dust particles/5 cm³
Taken at beginning of operation	5000
Taken approx. 20 sec later	4500
Taken approx. 60 sec later	4000
Taken approx. 30 sec later	1800
Taken approx. 30 sec later	580

It is seen that there is a progressive fall in count as the local dust cloud disperses. The first three figures are approximate only, the numbers of particles collected being too high for accurate counting.

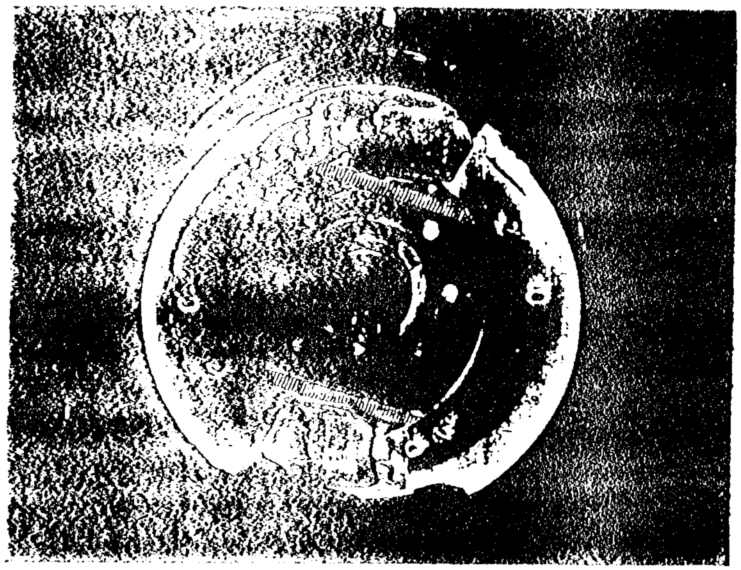

FIG. 1. Brake assembly before cleaning.

(facing p. 34)

A fixed sampling period of some 5 min was chosen for the determination of mass concentrations—this being longer than required for the blowing operation but sufficient to cover that required for the alternative cleaning methods. The dust collected by the static sampler close to the brake assembly gave an equivalent concentration of 114 mg/m^3 and that for the personal air sampler 42 mg/m^3. It is probable that many of the particles included were larger than respirable size. The few asbestos fibres counted on membrane filter samples gave a concentration of the order 3–5 $fibres/cm^3$.

ALTERNATIVE CLEANING METHODS

Initial approaches were to try the use of fixed and hand-held extractors to collect the dust particles removed by hand-brushing with a small paint brush. Fixed extractors, although reasonably efficient, were rejected because of restrictions which these placed upon the work by confining it to one area. Both operatives and supervision were unhappy about being confined to one work area—preferring to retain flexibility and carry out the work as they had previously done, wherever the vehicle happened to be. Portable extraction equipment was clearly required and after some preliminary enquiries, a BVC industrial vacuum cleaner was selected for use in experimental work. It is of fairly conventional type, powered by a ¾ h.p. motor and supplied with disposable paper bags in addition to the normal cloth bag. The paper bags are fitted in a manner which allows them to be sealed fairly easily before removal. To trap any particulates which might pass through the paper and cloth bags, an external, multi-layer filter was provided for fitting to the air outlet end of the cleaner. Preliminary experiments established that some brake dust particles were passing the paper and cloth bags but these were trapped by the externally fitted filter. Sampling at the exit side of the filter established that no particles passed the filter.

CONDITIONS OBTAINED USING THE VACUUM CLEANER AS A SOURCE OF EXTRACTION

The first technique tried was to use the nozzle of the cleaner, hand-held as a source of local extraction whilst the dust deposits were disturbed with a small paint brush held in the other hand. The Tyndall Beam showed that some dust was escaping into the environment. Objective measurements are summarized in Table 2.

TABLE 2. RESULTS OF KONIMETER SAMPLES DURING BRUSHING AND WITH LOCAL EXTRACTION

Sample	Number of brake dust particles/5 cm^3
Taken at start of process	1070
Taken about 1 min later	404
Taken about 2 min later	426
Taken at end of process	446

The fixed sampler in the area of the highest concentration gave a dust concentration of 21 mg/m^3 and the personal sampler, 2·7 mg/m^3.

An improvement in controlling the release of dust had been obtained but was not considered completely satisfactory and an alternative approach was sought.

CONDITIONS OBTAINED USING A MODIFIED TECHNIQUE

After some preliminary experiments, the following general technique was devised. Firstly, the loose deposits of dusts inside the brake drum and on readily accessible surfaces of brake shoes and the brake assembly were removed, using the smallest brush supplied with the cleaner—the equipment being used as a vacuum cleaner. A much narrower, tubular brush, made from available materials was then used to remove deposits from less accessible surfaces. Finally, a rag, soaked in water and wrung fairly dry, was used to remove adherent deposits. No visible emissions of dust were observed but a few particles were detected by the objective methods, as shown in Table 3.

TABLE 3. RESULTS OF KONIMETER SAMPLES DURING MODIFIED TECHNIQUE

Sample	Number of brake dust particles/5 cm^3
Brushing with standard brush	16–25
Brushing with tubular brush	20–25
Rag wiping	1–5

No fibres were detected and the mass concentrations involved were too low to determine.

CONCLUSIONS

The objective measurements made seem to confirm that vacuum cleaning provides a useful contribution towards obtaining satisfactory dust control when brake assemblies are cleaned. The design of the particular cleaner chosen prevents the discharge of particles back into the environment and the collection in a paper bag enables suitable disposal methods to be adopted. This work was completed in the early part of 1968 and subsequently the method described was recommended for use until such time as the results of studies being carried out elsewhere in the Motor Industry were known and detailed requirements subsequently formulated.

Acknowledgements—The assistance of Mr D. Smith of the Industrial Hygiene Department and Mr Young, Works Engineers, is gratefully acknowledged.

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INVESTIGATIONS INTO ALTERNATIVE FORMS OF CONTROL FOR DUST GENERATED DURING THE CLEANING OF BRAKE ASSEMBLIES AND DRUMS*

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INTRODUCTION

THE MOST usual method of removing the accumulated dust from brake drums and assemblies is by "blowing off" with a compressed air stream. This, of course, generates a dust cloud in which the operator works, proportionate in size to the drum/assembly being cleaned. We therefore investigated two alternative methods of controlling dust generated at a maintenance operation on commercial vehicles, as representing maximum likely exposure.

Enquiries at the beginning of the investigation indicated that the removal of dust is to allow inspection of the mechanism, rather than being a maintenance procedure in itself. Our efforts were, therefore, directed towards the removal of loose dust from the parts of the brake mechanism which needed inspection, rather than achieving total cleanliness.

The criteria for evaluating the two methods devised were firstly, that the alternative method did not take significantly longer than the method already in use, secondly, that it was not more difficult to carry out, and thirdly, that very little extra equipment was needed.

ALTERNATIVE METHODS EXAMINED

The alternative methods examined were a vacuum funnel, and a vacuum brush.

Vacuum funnel

The funnel (see Fig. 1) comprised a steel cone with a connection point at its apex for an industrial vacuum cleaner; a flexible skirt, with a draw string attached at its periphery; and a small-bore side-entry for the injection of compressed air. In use, the funnel was secured over the backplate of the brake assembly or over the drum and compressed air was injected to dislodge dust while the vacuum cleaner extracted dust-laden air. The assembly was rotated around the total circumference to complete the cleaning operation.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

Vacuum brush

The vacuum brush shown in Fig. 2 consisted of a circular nylon bristle brush mounted on an angled handle and fitted via the handle to the same vacuum cleaner. In use, the brush was used to remove dust from drums and assemblies under vacuum.

EXPERIMENTAL PROCEDURE

In order to determine which of these two methods was the better, the performance of each was compared with the traditional blow-off method, in two separate experiments shown in Table 1.

TABLE. 1. EFFECT OF CLEANING METHODS ON DUST CONCENTRATIONS

Hour / Activity		1 Back-ground	2 Blow-off	5 Back-ground	6 Funnel cleaning	6 Brush cleaning
Personal sampler	particles/cm³	116	422	107	415	
	fibres/cm³	0·96	5·35	0·95	3·5	
Static sampler	particles/cm³	161	72	162	210	
	fibres/cm³	0·45	0·52	0·41	0·75	
Peak sample	particles/cm³		41750		759	
	fibres/cm³		87		1·04	
Personal sampler	particles/cm³	125	635	140		158
	fibres/cm³	0·16	0·84	0·09		0·22
Static sampler	particles/cm³	129	155	110		122
	fibres/cm³	0·10	0·16	0·20		0·18
Peak sample	particles/cm³		41750			310
	fibres/cm³		87			0·57

During the first hour of the day air samples were collected to determine background concentrations; during this period the near side front road wheel was removed. In the second hour samples were collected during dust removal from the near side brake assembly by blow-off. Further background samples were taken during the fifth hour while the off side front road wheel was removed, and during the sixth hour dust determinations were made while either the funnel or the brush cleaning methods were used.

The personal samples were collected from the breathing zones of mechanics engaged in the work and static samples were collected concurrently to simulate exposure of mechanics working in an adjacent repair bay. Short duration samples were also collected by means of a Dräger pump from the operator's breathing zone at the peak period of dust generation.

All the samples were subsequently analysed for fibres in accordance with the technique laid down in the *Hygiene Standard for Chrysotile Asbestos* published by the British Occupational Hygiene Society (1968). Particle counts were limited to particles greater than 1 μ dia.

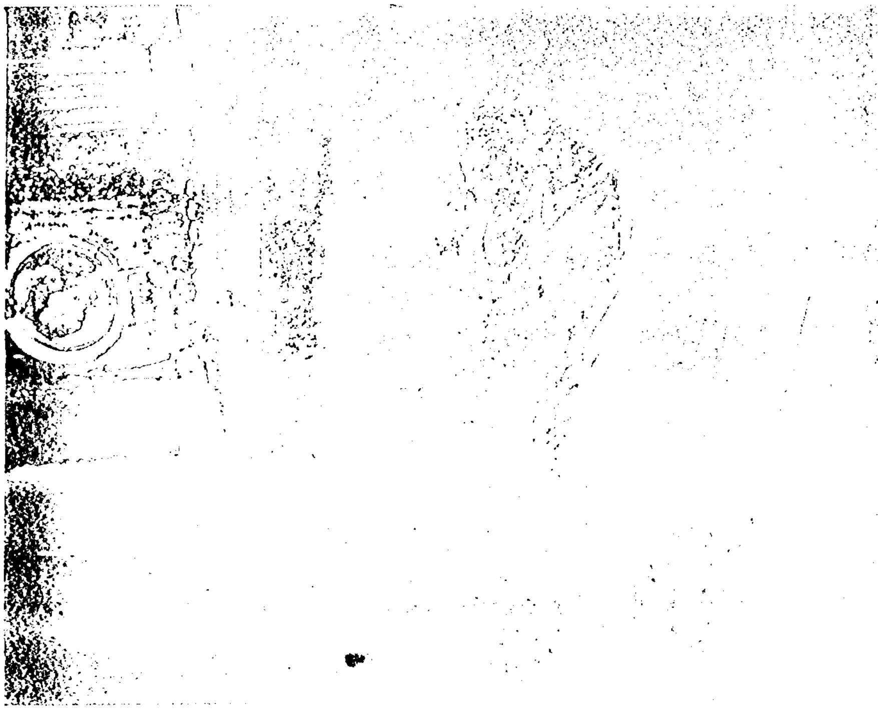

FIG. 1. [illegible]

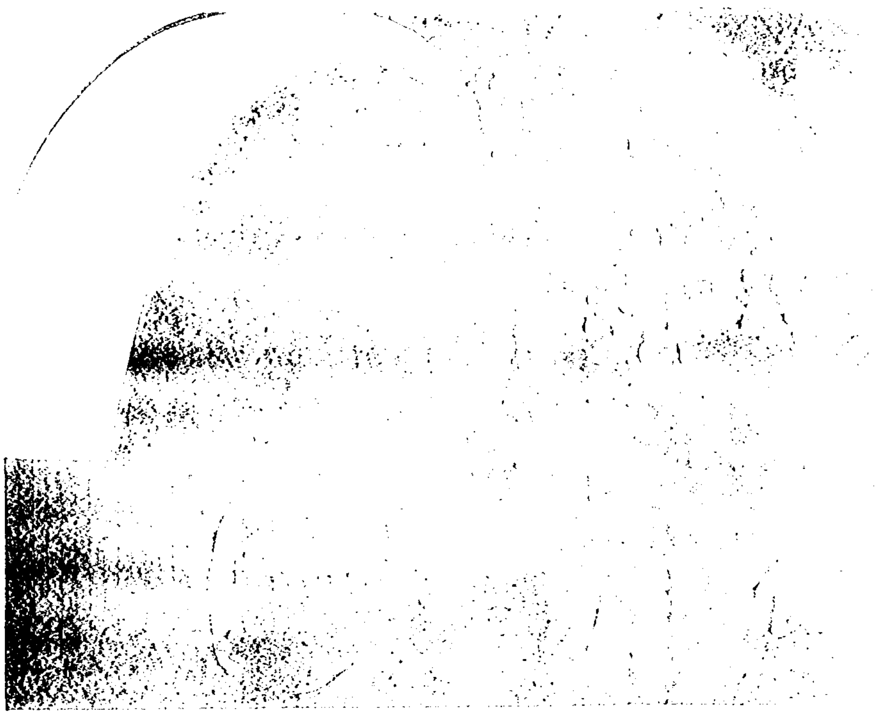

FIG. 2. Vacuum brush method of dust control.

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RESPIRATORS FOR PROTECTION AGAINST ASBESTOS*

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OVER the past few years the British Standard for Respiratory Protection, BS.2091, has been undergoing a drastic revision. A new Standard, BS.2091:1969, *Specification for Respirators for Protection against Harmful Dusts and Gases* has now been published and is of direct interest in regard to protection against dust including asbestos, as it places the standards of protection offered on a scientific basis.

It does this by controlling facepiece leakage as well as filter penetration and valve slip, so enabling the overall standard of protection to be assessed. For ordinary respirators this protection factor is of the order of 20, that is, the external concentration is reduced to one-twentieth that inside the facepiece. If we use the standards suggested earlier such respirators should afford protection against prolonged exposure to 40 fibres/cm^3 of chrysotile asbestos. This appears to be adequate to prevent danger during the operations of brake maintenance procedures, which we have been discussing today.

Perhaps I should mention that there is shortly to be published a new B.S. Specification *High Efficiency Dust Respirators*. These respirators will have a protection factor of 400 and will be suitable for short term protection against very high concentrations of chrysolite asbestos dust. Such respirators will be of the full facepiece or positive pressure type. Full facepieces are not, in general, acceptable for prolonged industrial use and the positive pressure dust respirator, while acceptable to the wearer, has a higher initial cost. A further British Standard *Positive Pressure Powered Dust Respirators* is in preparation, and should be issued later this year. It is unlikely however that during normal brake maintenance operations the concentrations of dust will be such as to require the use of equipment of this type.

An alternative approach is to utilise a half mask fed with compressed air from a suitable uncontaminated source. This type of apparatus offers complete protection for the wearer but suffers from the disadvantage of possible hose entanglement.

Respiratory protection should in general be regarded as providing protection for work where control is difficult or where the work is intermittent and of short duration. It is hoped that the control of the dust will be achieved by the methods indicated earlier and that respiratory protection will therefore only be needed for special work not of a routine nature.

*This paper was originally presented at a Conference on Exposure to Asbestos during Brake and Clutch Maintenance, held at Brentwood, Essex, March, 1969.

DISCUSSION

The results for the vacuum funnel *vs.* blow-off experiment and for the vacuum brush versus blow-off are shown in Table 1. It can be seen that the background concentrations during the fifth hour had re-established at the original level after a 2 hr latent period and therefore the blow-off operation carried out during the second hour did not affect the concentrations observed in the vacuum funnel samples collected in the sixth hour. The funnel appears to reduce personal exposure by 2 per cent for particles and 40 per cent for fibres; concentrations observed in the adjacent bay are increased and a reduction in peak concentrations of about 80:1 was achieved.

During the second experiment there was more variability in the background concentrations between the first and fifth hours but the effect of blow-off on the vacuum brush test may be discounted. Personal exposure by use of the brush is reduced by 75 per cent for both particles and fibres and the static samples show a reduction of 20 per cent for particles but an increase of 12 per cent for fibres. A reduction of 80:1 in peak concentrations was again observed.

CONCLUSION

The experiments demonstrated that the vacuum brush was better in reducing operator's exposure; it had the added advantages over the funnel of being easier to handle, consisted of fewer, simpler parts and was much quicker than the vacuum funnel.

There are three major reasons for the relative inefficiency of the funnel; its use increased brake cleaning time (and thus exposure time) by a factor of 8, it was difficult to obtain a good seal at the skirt, and imbalance occurred between the necessary air input and the capacity of the available exhaust system, with resulting leakage of dust.

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