AIA/7/3/PPOD

ASBESTOS AND HEALTH IN THE FRICTION MATERIAL INDUSTRY

The Problem

Exposure to asbestos dust is recognised as a potential occupational hazard. Among work people exposed to high concentrations of respirable asbestos dust, (such as is known to have occurred before present day dust control measures and work procedures were introduced) cases of cancer and asbestosis have been reported throughout the world. [1,2,3] The difficulty of reliably identifying the occupational history of those whose health has been affected many years after has resulted in any contact with asbestos being regarded with caution and all materials containing asbestos being attacked indiscriminately.

Since friction material is widely recognised as one of the products for which asbestos is an important ingredient, it has attracted such attention. Indeed, the asbestos industry, in reminding everyone of the vital role played by asbestos in brake linings, has stimulated such attention. Nevertheless the occupational health record of the asbestos friction material industry is good and only a few cases of asbestos-related disease are on record. However, the widespread use of friction material in all types of vehicles has raised the question of potential pollution of the environment with an assumed consequent danger to the health of the general public.

The friction material industry, therefore, has two basic problems. The first, the occupational health problem, has in many areas been resolved. However, the industry must continue to ensure that those employed in the manufacture of these materials are not exposed to dust levels which are harmful. An extension of this problem is the need to ensure that workers employed in the subsequent use of friction materials, either in the fitting of the products or the maintenance of vehicles, are not exposed to harmful dust levels.

The other problem for the industry, that of possible environmental pollution, is more difficult to resolve, based as it is on emotional anxieties (which are in no way justified by the evidence). A climate of concern for the effect on the environment of expanding towns and industries has led to the motor vehicle being included as a significant factor in this pollution. This fact together with the publicity given to asbestos and its classification as a carcinogen [4] have all combined to lead people to question the use of asbestos-based components in motor vehicles.

The automotive industry is also under attack for a number of other reasons, (e.g. pollution, waste of resources and congestion) and would gladly be without the asbestos problem although it must accept that for some years, current models of motor cars will need asbestos-containing material for replacements. The friction material industry itself must therefore dispel anxieties about asbestos-containing products in motor vehicles by ensuring that the existing reassuring evidence is made manifest and is properly understood.

Tackling the Problem

In order to tackle the problem most effectively, it is important that the origins, investigations and remedial measures involved should be well understood. This is especially necessary since the existence of the friction material environmental problem is to a large extent based on confusing two very different phenomena; on the one hand the occupational health experience and dust exposure data related to manufacture (and the subsequent fitting and servicing operations sometimes called "para-occupational") and on the other hand an assumed emission of similar dust into the general environment as a result of the daily wearing down of brake linings and clutch facings. An example of this confusion may be seen in the evidence given to the UK Asbestos Advisory Committee, where claims that the general public are at risk are supported solely by reference to a survey of motor vehicle maintenance workers.[5]

These facts will be reviewed under three headings, the first two covering the Occupational areas of Manufacturing and Servicing, and the third heading covering that of the General Environment.

Manufacture of Friction Materials

There is ample evidence to suggest that, in the manufacture of friction materials, the concentration of asbestos dust compares favourably with that found in most other modern asbestos operations. Within the last ten years efforts to observe a 2 f/ml* standard have led to further improvements in dust control and there are now many operations where levels well below this maximum allowable concentration are achieved[6]. Very few cases of asbestos-related disease arising from friction materials manufacture have been reported.

In evidence presented to the UK Advisory Committee,[5] Ferodo Limited, who have been using asbestos in brake and clutch linings since 1910, reported 8 cases of mesothelioma and 5 cases of asbestosis. The mesothelioma cases had all been exposed in the manufacture of railway brake blocks between 1928 and 1933 or during the war years up to 1943, to crocidolite as well as to the chrysotile asbestos more generally used throughout the plant. The asbestosis cases were all involved in mixing processes where masks should have been worn.

In the same volume of evidence, a report from the two Cape Industries' factories manufacturing both textiles and friction material (one since 1901 and the other since 1923) cites 9 cases of asbestosis and no case of mesothelioma.

Ferodo report that "many millions of man hours have been worked on finishing operations of asbestos-based materials; though the dust concentrations associated with these were at one time very high, there

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has not been a single diagnosis of asbestosis as a result of this exposure". In more recent years (1968 – 1976) however, average concentrations were well below 2 f/ml following continuous improvements in dust extraction methods.

An investigation in 1975 by Heidermanns, Kuhnen, Schutz and Prochazka[9] into dust hazards which might be associated with the manufacture and use of asbestos-containing friction materials (updated in the Research Report of the German Berufsgenossenschaften[7] quotes concentrations of micro-dust in the range of 0.09 to 0.20 mg/m^3 during grinding, drilling, sawing, turning and milling operations (the current TRK* value is 0.10 mg/m^3 or 2 f/ml:[8] on this basis the current range is 1.8 f/ml to 4 f/ml), on average just below or just above 0.15 mg/m^3 or 3 f/ml.

Such operations, unless subject to dust control, will emit dust containing asbestos. A number of surveys of such operations have been carried out in Germany [7,9], UK [10,11,12], USA [13,14,15,16,17] and elsewhere [3,5,8] and it is clear that, under some conditions of working and where such operations are carried out continuously, dust concentrations above 2 f/ml (or the TRK of 0.10 mg/m^3) can be reached. There is some evidence of effects on health among men engaged for a long period on such work. Medical and epidemiological investigations by Professor Woitowitz, Valentin and others [7] on workers who had been continuously exposed for at least 10 and up to 25 years to asbestos dust suggests a similar risk level for men employed on finishing operations (mainly grinding and drilling) in the automotive industry, to the risk level of workers in the manufacturing industry [7,9]. +

It was noted that the automotive industry group studied had had long exposure from a very early age. [9] A group of men carrying out brake

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+ Out of 94 workers (including 43 women) in manufacturing, there were 3 probable cases of asbestosis and 11 "possible". Among 63 men employed in finishing operations on brake linings in the automotive industry, 2 probable asbestosis cases were found and 10 "possible". ("Possible" maintenance services with exposure primarily during the cleaning and brushing out of brake drum dust gave little evidence of inhalation effects in spite of long years of exposure.

Professor Selikoff's investigations [19] quoted indications of abnormalities in 32 out of 87 motor vehicle mechanics (6 out of 29 with five or more years intermittent exposure showed signs on X-ray of changes consistent with asbestosis). Another report of the same investigation quoted ~~24%~~ of 93 brake service mechanics showing chest abnormalities not necessarily asbestos-related and it is emphasised that there were no confirmed cases of asbestos-related disease. Dust levels quoted in connection with this investigation (in USA) [20,21], refer to mean concentrations for blow-out of brake drums, grinding of used linings and bevelling of new linings of 15.9, 3.8, and 37.3 f/ml respectively - much higher than any found by any other researchers. No information is provided as to the duration of these samples - they are frequently referred to as peak concentrations or the mean of a number of such measurements. It is also clear that in the case of blowing out of brake drums, no asbestos fibres were visible by optical microscopy; some chrysotile was identified by X-ray diffraction. Fibres identified by electron microscopy were all below the minimum size specified in the definition of asbestos fibre (i.e. 5 µm in length)[8]. It should be noted that the methods of sampling and the criteria for measurement of occupational environments did not conform to the methods used by governmental agencies and by other investigators in Germany and UK.

For comparison, concentrations of asbestos dust during brake maintenance reported by Hickish and Knight [10] showed an average daily exposure of 0.68 f/ml (range 0.21 to 1.12) during brake service of 11 cars. During truck brake service, the average was 1.75 f/ml, with peak, during cleaning of the brake drum, of 7.09 f/ml.

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where machining was done without dust extraction. Although high concentrations of dust were observed during blowing out, no chrysotile asbestos could be detected by infra-red spectrometry, and the individual fibres which could be detected optically could not be identified as asbestos.

The General Environment

During the application of drum brakes, disc pads or clutch facings, small quantities of the surface of the friction material are worn away. These materials contain between 30% to 60% of asbestos, and it has been assumed by some that thereby large quantities of dangerous asbestos dust are being regularly discharged into the atmosphere. This, it is argued, creates a dangerous atmosphere akin to that which has produced asbestos-related disease (especially cancer) in some working environments. Since the estimated consumption of asbestos in friction material is annually over 40,000 tons [22] for Europe and over 50,000 tons in the USA the amounts involved are substantial. An estimate carried out by the Bendix Corporation with the support of the US Environmental Protection Agency (EPA) calculated that the amount of friction material worn away in brakes and clutches annually in the USA is around 60,000 tons,[13] (of which 37,000 tons is the asbestos content i.e. 60%. In Europe the content of brake linings is nearer 30%). However it is clear from measurements made at a number of locations with heavy road traffic that insignificant quantities of respirable asbestos dust are so emitted.[23,24]

The most important factor in dispelling anxiety is that the asbestos content of the wear products of friction material is not emitted into the atmosphere in the form of respirable asbestos dust. Indeed, a number of ambient air investigations indicate that it is difficult nowadays to find asbestos fibres in any significant quantity, regardless of size, in the atmosphere - even in the vicinity of asbestos manufacturing plants.[24]

Measurements of the ambient air even in heavy traffic conditions do not show any significant level of asbestos. Again, in underground railways confined tunnel environment might be thought to create the worst conditions, no significant build-up of asbestos dust has been detected.[24,25,26]

The explanation is simple and is confirmed by a number of careful scientific investigations. The heat generated in the process of applying the brakes or the clutch (the reason in fact why asbestos is such a vital component) is sufficient to destroy the original structure of the asbestos fibre. From a temperature of 450°C the chrysotile structure begins to convert to a non-crystalline amorphous phase, leading to a loss of stability of the fibre structure. The mechanical strain applied during the braking process has a pulverising and grinding effect, leading to disintegration of the fibre structure. The German report [7] calls it "a kind of micro-milling so that the dust no longer contains any fibres".

From a temperature of 650°C a new crystalline structure develops called Forsterite, which will be fully developed at temperatures of above 700°C. Generally, forsterite cannot be traced in brake lining dusts. This means that temperatures beyond 650°C either do not occur or are only very short-lived. The decrease of the chrysotile content, however, indicates that temperatures beyond 450°C are reached because the amorphous phase of the chrysotile cannot be traced analytically (by either infra red-spectrometric or X-ray diffratomatic methods).

Examination of the residue of wear products in brake drums confirms that the asbestos content is usually less than 1% of the residue.[27] It has been suggested that the dust escaping into ambient air may contain a higher proportion of the fine respirable asbestos than dust left in the drums but careful studies designed to entrap this escaping portion of the wear product show that this is not so. Various investigations into the amount of asbestos remaining in the residues from friction processes have been carried out which indicate how minute is the fraction of asbestos released in the application of friction. The latest report, [7] from Germany, confirms that technical investigations in recent years have repeatedly shown that the dust generated by friction of the linings in use - as opposed to dust created during the finishing and handling of new linings - as a rule contains only traces of free chrysotile fibre, i.e. of the order of 1%. The working party was unable to provide clearer infra-red spectrographical evidence of chrysotile. Under phase-contrast and electron-microscopic scrutiny, the dust contained just a few isolated fibres which could not even be definitely identified as asbestos. This is consistent with the investigation by UK government and industry investigations in 1969 [10,27] which reported that the free asbestos content of wear products of drum brake linings rarely exceeded 1%. (In disc brakes the content was even lower.)

The Bendix investigations for NIOSH in USA in 1973 gave a range from 1.65% to 0.003% - only three tests were above 1% and the overall average was 0.23%. This study also determined that only 3.2% of the asbestos content of all the wear products over the whole range of US motor vehicles became airborne - estimated at 5060 lbs. annually.[13]

The Ford Motor Company carried out a study [28] based on dynamometer tests which showed that during brake usage less than 0.02% of the lining wear was released in the form of free asbestos. The study estimated that concentrations of asbestos fibre in the urban atmosphere in the US due to brake usage was less than 0.07×10^{-9} g/m^3 (.07 nanograms) (less than one millionth of the 2 f/ml occupational control standard).

Measurements carried out at points of heavy traffic concentrations in the UK by the Asbestosis Research Council, under the observation of the TUC Centenary Institute of Occupational Health, also found no greater concentration. Even in the underground railway system, this survey found the asbestos content to be of the order 10^{-8} g/m^3 to 10^{-7} g/m^3. (10 ngs to 100 ngs/m^3)[24]

Finally, some observations made within the last three years by two eminent occupational health experts, on occupational risks and risks to the general public

Dr. John Gilson,[29] reviewing asbestos as an occupational hazard in a general group in which he includes friction materials, says "Despite the thousands of products containing asbestos, evidence of ill effects from their use is very small". He adds the qualification that occupations involving brake shoe maintenance have been shown to be at risk in the past. "Although most of the asbestos in brake shoes is degraded, the dust in the brake drums still contains a small percentage of asbestos". "The magnitude of the risk (of asbestosis and mesothelioma in those working regularly in this employment) is not known but is likely to be small." Professor Zielhuis,[22] in his report on public health risks, concludes "There is evidence of no excess risk of mesothelioma from asbestos pollution which has existed in the neighbourhood of chrysotile and amosite mines. There is no evidence of a risk to the general public at present". Later he repeats this view in his general conclusion "There is no established evidence that true ambient exposure, as prevalent in Western European countries, at this moment carries such a definite risk; however, there exist too many uncertainties to deny such a risk, though if the risk was substantial it is likely it would have been detected by now".

CONCLUSIONS

Manufacture

There can be an occupational health risk in the manufacture of asbestos-based friction materials. However, experience has shown that this is a very limited health risk and that it can be effectively controlled by well tested equipment and work procedures.

Standards based on extensive experience in the industry have been established and equipment is available to maintain these standards so that the occupational health risk can be controlled. In many countries these standards are enforced by legislation, but in any case trade and industry have an obligation, as with any occupational safety problem, to implement the effective risk prevention measures which have been developed by

Maintenance Work (Servicing)

In certain conditions involving servicing, etc., there may be a para-occupational hazard. The industry can provide information to ensure that users understand under what circumstances such risks can arise and how they can be avoided.[30,31.32,33]

The General Environment

The available data indicate that the general public is not at risk and means should be found to tell them so.

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14th January 1991

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Measurements of the ambient air even in heavy traffic conditions do not show any significant level of asbestos. Again, in underground railways confined tunnel environment might be thought to create the worst conditions, no significant build-up of asbestos dust has been detected.[24,25,26].

The explanation is simple and is confirmed by a number of careful scientific investigations. The heat generated in the process of applying the brakes or the clutch (the reason in fact why asbestos is such a vital component) is sufficient to destroy the original structure of the asbestos fibre. From a temperature of 450°C the chrysotile structure begins to convert to a non-crystalline amorphous phase, leading to a loss of stability of the fibre structure. The mechanical strain applied during the braking process has a pulverising and grinding effect, leading to disintegration of the fibre structure. The German report [7] calls it "a kind of micro-milling so that the dust no longer contains any fibres".

From a temperature of 650°C a new crystalline structure develops called Forsterite, which will be fully developed at temperatures of above 700°C. Generally, forsterite cannot be traced in brake lining dusts. This means that temperatures beyond 650°C either do not occur or are only very short-lived. The decrease of the chrysotile content, however, indicates that temperatures beyond 450°C are reached because the amorphous phase of the chrysotile cannot be traced analytically (by either infra red-spectrometric or X-ray diffratomatic methods).

Examination of the residue of wear products in brake drums confirms that the asbestos content is usually less than 1% of the residue.[27] It has been suggested that the dust escaping into ambient air may contain a higher proportion of the fine respirable asbestos than dust left in the drums but careful studies designed to entrap this escaping portion of the wear product show that this is not so. Various investigations into the amount of asbestos remaining in the residues from friction processes have been carried out which indicate how minute is the fraction of asbestos released in the application of friction. The latest report, [7] from Germany, confirms that technical investigations in recent years have repeatedly shown that the dust generated by friction of the linings in use - as opposed to dust created during the finishing and handling of new linings - as a rule contains only traces of free chrysotile fibre, i.e. of the order of 1%. The working party was unable to provide clearer infra-red spectrographical evidence of chrysotile. Under phase-contrast and electron-microscopic scrutiny, the dust contained just a few isolated fibres which could not even be definitely identified as asbestos. This is consistent with the investigation by UK government and industry investigations in 1969 [10,27] which reported that the free asbestos content of wear products of drum brake linings rarely exceeded 1%. (In disc brakes the content was even lower.)

The Bendix investigations for NIOSH in USA in 1973 gave a range from 1.65% to 0.003% - only three tests were above 1% and the overall average was 0.23%. This study also determined that only 3.2% of the asbestos content of all the wear products over the whole range of US motor vehicles became airborne - estimated at 5060 lbs. annually.[13]

The Ford Motor Company carried out a study [28] based on dynamometer tests which showed that during brake usage less than 0.02% of the lining wear was released in the form of free asbestos. The study estimated that concentrations of asbestos fibre in the urban atmosphere in the US due to brake usage was less than 0.07×10^{-9} g/m^3 (.07 nanograms) (less than one millionth of the 2 f/ml occupational control standard).

Measurements carried out at points of heavy traffic concentrations in the UK by the Asbestosis Research Council, under the observation of the TUC Centenary Institute of Occupational Health, also found no greater concentration. Even in the underground railway system, this survey found the asbestos content to be of the order 10^{-8} g/m^3 to 10^{-7} g/m^3. (10 ngs to 100 ngs/m3)[24]

Finally, some observations made within the last three years by two eminent occupational health experts, on occupational risks and risks to the general public [illegible]

Dr. John Gilson,[22] reviewing asbestos as an occupational hazard in a general group in which he includes friction materials, says "Despite the thousands of products containing asbestos, evidence of ill effects from their use is very small". He adds the qualification that occupations involving brake shoe maintenance have been shown to be at risk in the past. "Although most of the asbestos in brake shoes is degraded, the dust in the brake drums still contains a small percentage of asbestos". "The magnitude of the risk (of asbestosis and mesothelioma in those working regularly in this employment) is not known but is likely to be small." Professor Zielhuis,[22] in his report on public health risks, concludes "There is evidence of no excess risk of mesothelioma from asbestos pollution which has existed in the neighbourhood of chrysotile and amosite mines. There is no evidence of a risk to the general public at present". Later he repeats this view in his general conclusion "There is no established evidence that true ambient exposure, as prevalent in Western European countries, at this moment carries such a definite risk; however, there exist too many uncertainties to deny such a risk, though if the risk was substantial it is likely it would have been detected by now".

CONCLUSIONS

Manufacture

There can be an occupational health risk in the manufacture of asbestos-based friction materials. However, experience has shown that this is a very limited health risk and that it can be effectively controlled by well tested equipment and work procedures.

Standards based on extensive experience in the industry have been established and equipment is available to maintain these standards so that the occupational health risk can be controlled. In many countries these standards are enforced by legislation, but in any case trade and industry have an obligation, as with any occupational safety problem, to implement the effective risk prevention measures which have been developed by

Maintenance Work (Servicing)

In certain conditions involving servicing, etc., there may be a para-occupational hazard. The industry can provide information to ensure that users understand under what circumstances such risks can arise and how they can be avoided.[30,31.32,33.]

The General Environment

The available data indicate that the general public is not at risk and means should be found to tell them so.

Annex - Bibliography

14th January 1981

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