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ASBESTOS AIR POLLUTION RESULTING
FROM THE WEAR OF BRAKE LININGS

By

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ABSTRACT

Asbestos containing brake linings have been cited as a source of ambient air asbestos pollution. This paper reviews the suggestion and an estimate is presented which indicates that the asbestos emission from brake linings is significant. The ways in which this emission may be reduced or eliminated are briefly reviewed.

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INTRODUCTION

Recent interest in asbestos and the realization of its health hazard have raised the question of the extent to which people are exposed to asbestos on a non-occupational basis. Measurements have been made on urban background levels and it has been shown that small but definite concentrations are to be found in areas quite remote from any apparent source.

Since virtually every motor vehicles carries several pounds of asbestos contained in its brake linings and since these are worn away to some degree every time the brakes are applied then it is reasonable to expect that they could present a significant emission source. This is especially acceptable when one considers the 100 million or so vehicles on the nations roads.

The paper investigates the possible extent of such emissions and presents an estimate of the contribution to urban asbestos concentrations. Possible means of reducing such emissions by use of an alternative or sealing the system are briefly reviewed.

The Extent of the Emission

The best information available at the present time[1,2] indicates that the percentage of asbestos contained in the dust normally emitted from brake linings is of the order of 1%. However, under conditions of severe breaking, this may rise to 15%.

The average brake friction material contains of the order of 50% asbestos, thus an explanation is necessary to account for the discrepancy between the measured and theoretical values. The most likely explanation results from the known facts with regard to heat generated at friction surfaces. The work of Bowden and Tabor[3] has shown that when two surfaces are placed together the contact area is dramatically less than the apparent area.

This means that very large energy transfer takes place at these contact points and extremely high temperatures are reached.

In the case of brake linings, some evidence of these temperatures has been generated in unpublished work by the General Motors Company[4]. In this study, a small hole was cut through a brake shoe and the radiation collected from the exposed shoe surface was monitored. The results suggested that under light braking temperatures of the order of 800-900°C were found, while during heavy braking the temperature reached 1700-1800°C.

The significance of this data to the present case is that it is known that asbestos decomposes above 500°C[5] to give forsterite (Mg_2SiO_4), talc ($Mg_3Si_4O_{10}(OH)_2$) and water vapor.

Acceptance of the value of 1% of asbestos emitted allows an estimate to be made of the effect of this emission on the quality of the atmosphere.

Estimation of Urban Concentrations of Asbestos From Brakes

Assumptions

a. There are approximately 100 million* motor vehicles.

b. Motor vehicles have an approximate average weight of 4 lbs of friction material, when new, of which 50% is asbestos.

c. The average motor vehicle will require replacement of the brakes after three years of use at which time they will have lost 50% of their weight by abrasion.

d. The dust emitted will contain 1% of asbestos fibers.

e. Of the wear dust, 80% is emitted and 20% is lodged within the system.

*The AAA claims there are 109,000,000 licenced vehicles including 90,000,000 passenger vehicles and 19,000,000 trucks.

Calculation

The total weight of brake linings in use is

$$\frac{100,000,000 \times 4}{2000} = 200,000 \text{ Tons.}$$

The quantity worn off these linings per year follows from the assumptions made in c.

$$\text{as } 200,000 \times \frac{1}{3} \times \frac{50}{100} = \frac{200,000}{6} \text{ Tons/yr.}$$

This wear dust contains 1% asbestos, hence emission is

$$\frac{200,000}{6} \times \frac{1}{100} = \frac{2000}{6} \text{ Tons/yr.}$$

Allowing for the fact that 20% is not emitted, the total emission is thus

$$\frac{2000}{6} \times \frac{80}{100} = \frac{1600}{6} = 270 \text{ Tons/yr.}$$

Effect on the Atmosphere

There are no facts relating directly to asbestos on which one may judge the effect of these emissions on urban air. However, there has been a considerable amount of study done on the diffusion of other materials from automobiles, particularly lead and carbon monoxide. At a recent ACS Symposium in Minneapolis[6] evidence was presented which placed the level for lead emission at 0.01 $\mu g/m^3$ in Thule, Alaska and 2.5 $\mu g/m^3$ in New York City. Next to busy highways a level in excess of 50 $\mu g/m^3$ may well be possible. In the light of this data the value of 2 $\mu g/m^3$ for average urban air conditions, suggested by GM[4], seems eminently reasonable. Considering that 1.25×10^5 tons of lead are emitted in total from automobiles then the following factor is used.

$$\begin{array}{l}\text{Avg. Conc. asbestos}\\ \text{in city air from}\\ \text{automobiles}\end{array} \approx \begin{array}{l}\text{Quantity of}\\ \text{asbestos}\\ \text{emitted}\end{array} \times \frac{2\ \mu g/m^3 \text{ city air}}{1.25 \times 10^5 \text{ tons Pb from cars}}$$

Applying this figure to the present case and assuming that 200 tons are emitted in city areas, then we get that:

$$\text{The avg. conc.} \approx 200 \times \frac{5}{1.25 \times 10^5}$$

$$\approx 3.2 \times 10^{-3}\ \mu g/m^3$$

$$\text{or} \approx 3.2 \times ng/m^3$$

A similar result is obtained using the dispersion factor for carbon monoxide. However, the values for lead are preferred since it is a particulate emission rather than a gas.

The Significance of This Value

The question of whether asbestos containing brake linings constitute a significant source of ambient air background, asbestos levels can now be considered.

Firstly, it is pertinent to review the available evidence on asbestos levels in ambient air. Perhaps the most up-to-date information is reported in a recent paper by Thompson and Morgan of the EPA[7]. Their data suggests that values 0.5-15 ng/m^3 are appropriate to urban sites, while 0.1 ng/m^3 is to be found in nonurban sites. They give a figure of 0.01 ng/m^3 for remote sites.

The California State Health Department in collaboration with the School of Public Health, Berkeley, California, have tested ambient air for asbestos. Their results suggest values of 0.06 ng/m^3 in remote sites and 3 ng/m^3 near a source.

Nicholson and Rohl[8] of the Mt. Sinai School of Medicine have also been active in the measurement of asbestos in urban ambient air. The analysis of a large number of samples has revealed that 33% of the samples contained 0-0.9 ng/m^3, 55% contained 1.0-5.0 ng/m^3 and 10% contained 5-20 ng/m^3 and a few were in excess of this.

All of the workers have been at pains to point out that the results are to be considered preliminary. Thus they should be regarded not as final definite figures, but rather as good, considered, preliminary findings. The similarity of the figures reported by the various workers does suggest that at least an order of magnitude has been established.

Consider now the estimate of 3.2 ng/m^3 calculated previously as the contribution from asbestos brake linings. Firstly, it should be stated that this figure is a conservative estimate and allowance has been made for the many factors which could reduce this figure. Secondly, although there is no reason to doubt the factor for the diffusion of lead, it should be realized that this figure is an average value for the whole of the city air. Consequently, much higher concentrations are to be expected in certain areas of high brake usage. For example, near intersections, tollbooths, etc.

In the light of the evidence here presented, one must conclude that asbestos emitted from brake linings may be a major contributing factor in the overall ambient air concentration.

Further work is necessary to establish more definitely the major contributors to urban asbestos concentration levels. It is not possible to state with assurance how much these low concentrations of asbestos constitute a threat to the health of the general public. Medical evidence and opinion is widely divergent on this issue. However, asbestos has been rated as a hazardous substance by the EPA and as such it should be treated with due respect. Emissions should be reduced or curbed wherever this is possible. To this end it is worth briefly reviewing how this may be achieved.

TECHNOLOGY OF ELIMINATING EMISSIONS

The emission of asbestos to the atmosphere from asbestos containing brakes could be prevented in two ways: its use could be banned altogether, or, the brakes could be sealed. In the former case, an alternate would have to be found.

Alternatives to Asbestos

For a replacement to be as suitable as asbestos, it would have to fulfill a list of desirable features as:

- Resist high temperatures without degradation or loss of frictional properties.
- Combine excellent friction characteristics without severe abrasion.
- Provide great strength - asbestos fibers have a greater tensile strength than steel and yet are more flexible.
- Have relative economy.

Of the materials which have been considered, sintered metal with ceramics and fiberglass have been the most likely candidates thus far.

Sintered Metal - This material has been used and indeed has the desirable quality of being fade-free, for this reason it is still used in some racing cars. However, it has several disadvantages. It tends to be noisy and brake screetch is a problem. They suffer from what is known in the trade as "morning sickness", this means that the first stop is very severe, or, that the cold friction is high. Wear is higher than with asbestos and thus the brakes have to be replaced more frequently. Replacing the brakes is more difficult since all brakes are honed to fit the drum. Honing metal is more difficult than asbestos friction material.

Ceramic Metal (Cermets) - A sintered metal and ceramic composition has been developed and tried. Its use at this time seems to be restricted to the clutches on heavy-duty vehicles (tractors, etc.); in these cases it is usual to use buttons of the material rather than a complete annulus. Although to a lesser degree, it suffers from the same complaints as sintered metal with respect to noise, wear and severe first stop, and in addition, it is relatively expensive. However, its anti-fade characteristics have led to extensive testing. For example, the Ford Motor Company put inserts of ceramic metal at the position of maximum brake wear on their 1958 Thunderbird. The concept was abandoned, reportedly due to uneven braking leading to a directional pull when braking.

Fiberglass - Attempts to use fiberglass instead of asbestos have been attempted since 1938. So far, no design has met the exacting standards required. As with the other materials, the first stop is harsh. Apparently the design is better for disc brakes than drums. A problem is the sensitivity of the brake to moisture.

Owens-Corning are undertaking development research in this area. They are very guarded with regard to the status of their work, but state that they are actively engaged in developing a product. To date, no vehicles are known to employ fiberglass in their brake friction product.

Sealed Systems

Sealed systems have been seriously considered. Normally, cars rely on air cooling and the movement of air round the brake caused by the motion of the car. However with high performance cars, more cooling is required. This is achieved in a simple manner by fabricating a superstructure which scoops up air and directs it inside the brake drum. If a filter were added on the exiting side, this would cause a substantial reduction in emissions.

A more elaborate design which has been used is to liquid cool the brake system. This enables the braking system to be completely sealed and thus no emission are possible. The one problem area with this design is that the oil seals must be extremely reliable. However, with a well designed system problems due to overheating could be largely eliminated.

CONCLUSIONS

An estimate has been made of the asbestos concentrations to be found in urban air resulting from the use of asbestos containing brake materials. The results indicate that brake use may well constitute a major source of asbestos background levels. The quantity in comparison to occupational levels is extremely low. A time weighted average occupational exposure level of 5 f/cc would be of the order of 100,000 times greater than a background level of 3.0 ng/m^3. The medical significance of these results is not known with any certainty.

At the present time, no alternative to asbestos containing friction products is developed to the stage of finesse required by the industry. It is difficult to believe that modern technology cannot overcome the problems presented by the use of alternates.

The use of sealed brake units is a second possibility. Again there do not seem to be any insurmountable technological problems, but no information is available as to the cost and time factors.

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