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Brake Lining Decomposition Products

A number of investigators have found asbestos bodies in the lungs of urban residents who were not occupationally exposed to asbestos. A relationship between the carinogenic properties of asbestos and the urban excess of lung cancer has been suggested. The decomposition products of brake linings have been described as a possible source of these fibers. Brake testing laboratory methods were used to test fiber emission from a variety of friction products. Only a very small fraction of the asbestos escaped as free fiber while the remainder was transformed into some other, nonfibrous, mineral. A significant release of free fiber occurred only under conditions extreme enough to produce brake failure.

Table I. Asbestos bodies in human lungs.

Location	Year	% Positive
Cape Town (2)	1963	26
Miami (2)	1965	27
Pittsburgh (3)	1965	41
Johannesburg (4)	1965	39
Finland (5)	1966	58
Montreal (6)	1966	48
San Francisco (1)	1966	42

Table II. Brake lining composition.

Ingredient	Automobile	Truck
Asbestos	55	33
Resins and polymers	28	48
Oxides and pigments	9	16
Metals	3	2
Carbon, graphite, etc.	5	1
	100%	100%

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The occurrence of coated fibers referred to as "asbestos bodies" in the lungs of urban populations not occupationally exposed to asbestos has been noted by several investigators. The results of several autopsy series, as summarized by Cooper,[1] are shown in Table I.[1–6] Thompson,[7] in suggesting possible modes of exposure that could account for these bodies, stated:

> The average private motor vehicle wears out three or four sets of brake linings and one or two clutch linings in its lifetime, and commercial and public transport vehicles wear out many more. These linings consist largely of asbestos which is ground to dust as the linings wear, and most wear occurs in built-up areas. This alone in most cities would involve the discharge of many tons of asbestos dust and fibers in the streets each year.

Since asbestos has been implicated as a carcinogen[8] and lung cancer has a higher incidence[9] among urban populations, the fate of the asbestos worn from brake linings becomes significant.

Brake Lining Composition

The average composition of typical brake linings of the type tested is shown in Table II. Individual mixes may vary considerably from these averages.

Each of these ingredients performs a particular function. The asbestos provides strength, heat resistance, and selective decomposition under stress. The resins and polymers hold the other ingredients together. Various oxides are added as pigments and to improve the grip of the lining on the drum. Soft metals such as lead and brass improve wear while carbon and graphite serve as friction modifiers.

Brake lining quality depends to a large extent on the type of binder used. Linseed oil, which begins to decompose at about 450°F, is used for light service brakes. More demanding service requires brakes made from cashew type resins or oil modified phenolic resins. These ingredients are mixed, either dry or with a solvent added, formed into shape, and cured in an oven. The hardened lining is then cut, ground, and sanded to the precise dimensions of the finished linings. The dust produced by the abrading operations in asbestos friction product factories (Figure 1) contains free asbestos fibers that are similar to those in industries where cancer is known to be in excess.[10] The question to be resolved, therefore, is whether the dust produced by the normal wear of brake linings contains this same type of free asbestos fiber.

Test Methods

In an initial exploratory survey, the dust obtained from inside automobile brake drums removed for brake relining was examined by electron micrograph. Figure 2, which is typical of the series, does not reveal any free fibers. However, this finding did not eliminate the possibility that free asbestos fibers were released and that they had escaped into the atmosphere. To examine this hypothesis a series of experiments was devised to permit sampling decomposition products of the lining under simulated operating conditions. The tests (Table III) were performed with the brake testing machines in the laboratory of a major brake lining manufacturer. Most of the tests were performed on a

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Figure 1. Brake lining factory dust.

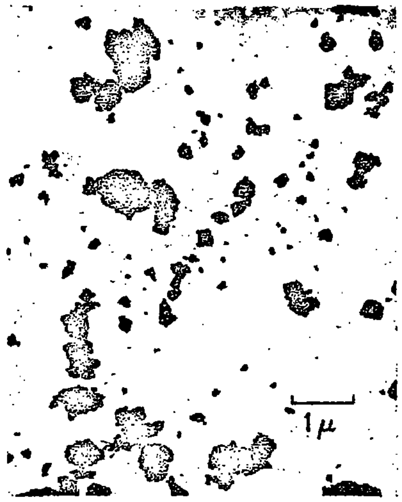

Figure 2. Dust removed from brake drum.

Figure 3. Decomposition product from normal wear of brake lining.

friction-testing machine which used one-inch-square samples of the test lining. Heating and cooling apparatus permitted control of drum temperature from those encountered with intermittent brake use to the maximum temperature which occurred only in extremely rapid or "panic" stops from high speed. Other tests were performed on a brake-testing dynamometer which subjected a complete brake assembly to a series of stops and starts from different speeds and at different deceleration rates to simulate actual driving conditions. In these tests the drum temperatures varied according to the driving condition simulated. During each run at a test condition, a sample was collected on an 0.8 μ pore size membrane filter. Electron micrographs of these filters were examined to determine the presence of free asbestos fibers and to quantify these fibers when more than a few occurred.

Results

The object of the tests was to determine what proportion of the asbestos known to be present in the lining appeared as free fiber in the decomposition product. No attempt was made at a mass balance between the material worn from the lining and the decomposition product since it was not possible to collect all of the decomposition product. However, the percentages obtained in the fraction of decomposition product examined are applicable to the total material worn from the brake and may be compared to the percentage of asbestos originally present.

In all but a few tests the automobile drum brake linings showed less than 1% free fiber in the decomposition product as compared to about 50% in the lining. An electron micrograph of the decomposition product obtained from a typical test in this group is shown in Figure 3. In those tests where a significant mass of free fiber was released (Figure 4), the temperature was in an extremely high range for the lining in question as evidenced by rapid drop in the coefficient of friction. Had these linings been subjected to like conditions in a vehicle, the brakes would have failed.

Similar results were obtained in the bus and truck drum brake tests and in the clutch test. The experimental model disk brake tested did release some (>5%) free fibers, but no conclusion can be drawn from a single sample.

Discussion

Except in all but the most extreme driving conditions, only a very small fraction of the 30 to 50% asbestos present in a brake lining escapes into the atmosphere as free fiber. The question remains: What happened to the asbestos? A prevalent theory of brake operation holds that wear occurs not by abrasion of the lining by the drum but by the production of minute areas of intense heat at the points of contact between the drum and the lining. Decomposition, not only of the binder but of the asbestos as well, occurs at these locations since the breakdown temperature of asbestos, about 900°F, is exceeded. Decomposition products will include not free asbestos fibers, but a different mineral resulting from thermal metamorphosis of asbestos.

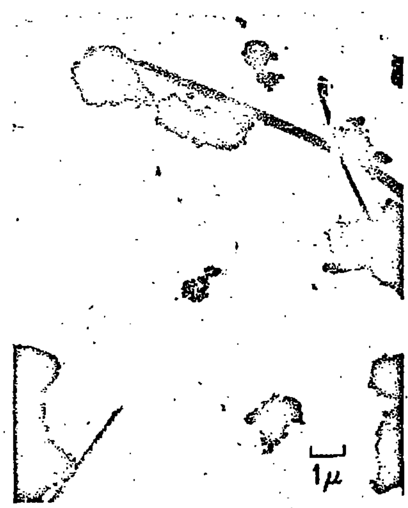

Figure 4. Decomposition product from brake lining at failure.

Table III. Test results by electron micrograph.

	Product	Brand	Test Method	No. of Samples	Conditions of Test-F	Presence of Free Fibers	% Free Fiber[a]
1.	Automobile drum brakes	A	Friction	6	300-800	Few	<1
2.	Automobile drum brakes	B	Friction	6	250-800	None	0
3.	Automobile drum brakes	C	Friction	5	300-700	Few	<1
4.	Automobile drum brakes	C	Friction	1	700-900	Numerous	~10
5.	Automobile drum brakes	D French	Friction	5	300-800	Few	<1
6.	Automobile drum brakes	E	Friction	5	300-700	Few	<1
7.	Automobile drum brakes	F German	Friction	5	300-800	Few	<1
8.	Automobile drum brakes	G	Friction	2	100-500	Few	<1
9.	Automobile drum brakes	G	Friction	1	600-700	Numerous	~15
10.	Automobile drum brakes	H	Friction	2	100-600	Few	<1
11.	Automobile clutch	J	Dynamometer	1	Normal driving	None	0
12.	Automobile disk brake	K	Dynamometer	1	Normal driving	Few	<5
13.	Bus drum brake	L	Dynamometer	1	City driving	None	0
14.	Bus drum brake	M	Friction	2	450-550	None	0
15.	Truck drum brake (light)	F	Friction	10	300-800	Few	<1

[a] Weight estimated from fiber volume.

Some independent experiments done at a brake lining research laboratory[11] have shown that all of the magnesium present in the chrysotile asbestos originally in the lining can be accounted for in the decomposition products. However, the characteristic X-ray diffraction pattern of chrysotile asbestos had vanished. Thus, it is apparent that under conditions in which asbestos is worn from the lining of a brake, the asbestos is destroyed.

Conclusion

Only a very small proportion of the asbestos worn from brake linings is released as free fiber; the remainder is converted into some other mineral as a result of the extreme temperatures generated at small spots on the lining surface. Thus, although urban air contains a few free fibers as a result of brake lining wear, they represent a very small proportion of the total asbestos used in manufacture of brakes. Many sources of respirable fibers not associated with asbestos products have been identified,[12] and free fibers from brake lining wear seem to be an inconsequential health factor in urban air pollution.

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