Jeremiah R. Lynch
National Center for
Urban and Industrial Health

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%

Mr. Lynch is Chief of the Laboratory of Engineering, Occupational Health Program, Public Health Service, Department of Health, Education, and Welfare, 1014 Broadway, Cincinnati, Ohio 45202.

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 in 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, dust obtained from inside automobile brake drums removed for brake relining was examined by electron microscopy. Figure 2, which is typical of the results, 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. These tests (Table III) were performed with dynamic brake testing machines in the laboratory of a major brake lining manufacturer. Most of the tests were performed

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.

References

1. Cooper, W. C., "Asbestos as a hazard to health," *Arch. of Env. Health*. 15: 285 (1967).
2. Thomson, J. G., Kaschula, R. O. C., and McDonald, R. R., "Asbestosis as a modern urban hazard," *S. Afr. Med. J.* 37: 77 (1963).
3. Cauna, D., Totten, R. S., and Gross, P., "Asbestos bodies in human lungs at autopsy," *JAMA*, 192: 37 (1965).
4. Webster, I., in discussion of Thompson, S. F., "Physiological effect of D_2O in mammals," *Ann. N. Y. Acad. Sci.*, 84: 736 (1960).
5. Meurman, L., "Asbestos bodies and pleural plaques in a Finish series of autopsy cases," *Acta Path Microbiol. Scand Suppl.*, 181: 107 (1966).
6. Aryilrel, L. and Thurlbeck, W., "The incidence of asbestos bodies in the lungs of randon autopsies in Montreal, Canada. *Med. Assoc. J.*, 95: 1179 (1966).
7. Thomson, J. G., "Asbestos and the urban dweller," *Ann. N. Y. Acad. Sci.*, 132: 196 (1965).
8. Selikoff, I. J., Churg, J., and Hammond, E. C., "Asbestos exposure and neoplasia," *JAMA*, 188: 22 (1964).
9. Buell, P. and Dunn, J. E., "Relative impact of smoking and air pollution on lung cancer," *Arch. of Env. Health*, 15: 291 (1967).
10. Enterline, P. E. and Kendrick, M. A., "Asbestos dust exposures at various levels and mortality," *Arch. Env. Health*, 15: 181 (1967).
11. Sinclair, D., "Study of wear dust from brake lining," Johns-Manville Res and Eng Ctr., personal communication (1967).
12. Cralley, L. J., Keenan, R. G., Lynch, J. R., and Lainhart, W. S., "Source and identification of respirable fibers," Amer. Ind. Hyg. Assoc. J., 29: 129 (1968).