Brake Lining Manufacture

Ex. #	Date	Citation	Findings
	1935	Lanza, McConnell, Fehnel. "Effects of inhalation of asbestos dust on the lungs of asbestos workers" Publ. Health. Rep. 50:1-12	High prevalence of asbestosis among workers with "more than 3 years of employment in the industry" at five plants including one where molded brake band and clutch friction materials were manufactured
	1935	Fulton, et al. Asbestosis. Harrisburg, Penn.: Dept of Labor and Industry, Commonwealt h of Penn.	Report of 25 percent prevalence of asbestosis among selected workers at four asbestos fabricating plants, including three where brake linings were manufactured.
	1939	George, A.W., R.D Leonard. "An X-ray study of the lungs of workmen in the asbestos industry covering a period of ten years" Radiology 33:196-209	Documents asbestosis in brake lining manufacturing workers since 1928, with compensation. Explains that the asbestosis cases seen by Hawes *(New Engl. J. Med. 216:162-165,* 1937) were brake lining manufacturing workers. Discusses switch from dry to wet methods of processing.
	1940	Stone, M.J. "Clinical Studies in asbestosis" Amer. Rev. Tuberc. 41: 12-21	Asbestosis in 148 brake-lining manufacturing workers seen by Drs. Stone and Hawes.
	1940	Stone, MJ. "Studies in asbestosis." Dis. Chest. 6: 170-171	Asbestosis in 148 brake-lining manufacturing workers seen by Drs. Stone and Hawes.

Grinding and Drilling Brake Linings—Early Papers

Ex. #	Date	Citation	Title	Findings
	1934	Osborn. Forty-Ninth Report of the State Department of Health, State of Conn. Public Document No. 25, Hartford, CT. pp. 507-511		Describes the grinding of molded asbestos brake and clutch parts under varying degrees of local exhaust ventilation. Total dust counts ranged from 0.6 to 17 MPPCF. The need for dust sampling and analysis to evaluate these exposures was stressed, as the visual appearance of the worst grinding exposure was unremarkable.
	1935	Memorandum on the Industrial Diseases of Silicosis and Asbestosis. London: H.M. Stationery Ofc.		Lists under "Industries and Processes in which asbestosis occurs...the sawing, grinding, and turning in the dry state of articles composed wholly or partly of asbestos such as motor car brake and clutch linings..."
	1940	Brachmann. "Asbestosis in grinders and drillers of brake bands" Arbeitsschutz 172-174		Clinical and X-ray examination showed asbestosis in nearly all workers employed 5 years or more as grinders and drillers of brake linings.
	1941	Brachmann. Abstract in "Abstracts" supplement to J. Indust. Hyg. Tox. 23:76-77		Clinical and X-ray examination showed asbestosis in nearly all workers employed 5 years or more as grinders and drillers of brake linings.
	Feb. 1948	Castrop, V.J. "Fume and dust exposure" Nat. Safety News.		By General Motors industrial hygienist. Section on asbestos noted that brake lining grinding and "surfacing" operations were equipped with local exhaust ventilation Systems.
	1957	Thomas, D.L.G. "Pneumokoniosis in Victorian Industry" Med. J. Australia 1:75-77		The following occupations (involve asbestosis hazards)...sawing, cutting and finishing any product containing asbestos—for example, brake linings, asbestos sheeting, and various insulating materials...
	1963	Patty, F.A. Industrial Hygiene and Toxicology, New York: Interscience (2d ed.) pp. 2243-2244		Written by former director of Industrial Hygiene Dept., General Motors. "The sawing, filing, drilling, and grinding of brake linings is ordinarily well controlled... It is desirable in asbestos exposures to keep the dust count down to 5 million particles, or less, per cubic foot of air."

Compensation

Ex. #	Date	Citation	Findings
	1965	McVittie, J.C. "Asbestosis in Great Britain" Ann. NY Acad. Sci. 132:129-138	Describing the occupations of workers diagnosed with asbestosis (and compensated for disability) in the years 1955-1963, he lists "brake lining" workers with an average of 14 years' exposure.
	1979	Smither. "Surveillance of High-Risk Groups – A Survey of Asbestos Workers: The Present Position in the UK" Ann. NY Acad. Sci. 330: 525-532	Updates McVittie's figures through 1969, showing that the four U.K. Pneumoconiosis Panels diagnosed 10 cases of asbestosis in "brake lining" workers in the years 1963-1969.

Asbestos Air Pollution Hazard from Brake Ware

Ex. #	Date	Citation	Findings
	1963	Thomson, J.G., R.O.C. Kaschula, and R.R. MacDonald. "Asbestos as a Modern Urban Hazard," S. *Afr. Med. J.* 37:77-81	Expresses fear of public cancer hazard from asbestos released into the air of cities by brake wear.
	1963	"Pulmonary Asbestosis," *S. Afr. Med. J.* 37:629-630	Editorial expresses similar concerns to Thomson's
	1968	Lynch, J.L. " Brake lining Decomposition Products," J. *Air. Pollut. Contr. Assoc. 18:824-826*	Electron micrograph showed no free fibers in accumu lated brake drum dust. Testing was then done on dust released by braking, using equipment of a brake lining manufacturer. The apparatus permitted simulation of stopping using complete brake assemblies. In all but a few tests the automobile drum brake linings showed less than 1% free fiber in the decomposition product... In those tests where a *significant* mass of free fiber was released, the temperature was in an extremely high range for the lining in question as evidenced by the rapid drop in the coefficient of friction...(under which conditions the brakes would have failed)... Similar results were obtained in the bus and truck drum brake tests...

Remaining Chronology of Papers Relating to Asbestos Hazard in Brake Repair (through 1985)

Ex. #	Date	Citation	Findings
	1961	Hueper, W.C. "Carcinogens in the Human Environment," *Arch. Path,* 71:237-267	Lists brake linings under, "operations and products with contact to asbestos for producers, processors, users, consumers, residents." Lists as a population with occupational and environmental exposure, in italics, "brake linings producers."
	1965	Hueper, W.C. "Occupational and Nonoccupational Exposures to Asbestos," *Ann. N.Y. Acad. Sci.* 1.32:184-195	Table lists "garage attendants" under the heading of groups occupationally exposed to asbestos and lists brake linings as a source of general environmental asbestos exposure.
	July 1968	A Preliminary Investigation." Indust. Hyg. Foundation—Report for Johns-Manville. Unpublished.	The index card for document no. 3071 at the Institute for Occupational and Environmental Health, library of the Quebec Asbestos Mining Association in Montreal, recorded the authors' summary: "Brake-drum dust has evoked a pulmonary response which suggests that this dust is biologically 'inert.' Brake-drum dust is capable of producing ferruginous bodies in the lungs of hamsters that are indistinguishable from asbestos bodies." Handwritten on the card are the phrases, "Not to circulate!" and "Scientific Committee only." The library is now part of the Asbestos Institute in Montreal.
	1969	Gross, P. and R.T.P. de Treville. "Pulmonary Ferruginous bodies/Studies on Their Origin, *Pizeninoconiosis Proceedings' of the International Conference Johannesburg*. H.A. Shapiro, Ed. Cape Town, South Africa: Oxford University Press, 1970, pp.86-91.	(O)f the 6 ferruginous bodies isolated from hamster lungs injected with brake drum dust, all gave an electron diffraction pattern characteristic of chrysotile; this, in spite of the relative paucity of fibers in the dust by optical microscopy and the negative X-ray diffraction pattern of the powder. These 6 ferruginous bodies were, therefore, asbestos bodies.
	1969	Sullivan, R.J. and Y.C.	Refers to Newhouse and Thompson's report of mesothelioma "in a mechanic."

Ex. #	Date	Citation	Findings
		and Y.C. Athanassiadis. *Preliminary Air Pollution Survey of Asbestos.* Litton Systems, Inc. report prepared for the National Air Pollution Control Adminis-tration, p.32	
	1970	McDonald, A.D. *et al.* "Epidemiology of Primary Malignant Mesothelial Tumors in Canada." *Cancer* 26:914-919	In a retrospective review of the potential asbestos exposures of a series of mesothelioma patients in Canada, "Men employed in... the installation of brake linings...were responsible for most of the excess of cases over controls." In a tabulation of the "occupations classified under definite or probable exposure to asbestos," are 21 cases of mesothelioma, including 2 who did "brake lining installation" and one more who worked in brake lining manufacture. This study attributes the main risk of mesothelioma to asbestos exposure in manufacturing and product use, as opposed to the mining of chrysotile asbestos. Funded by Quebec Asbestos Mining Association.
	1970	Smither, W.J. "Asbestos and Asbestosis." *Annals of Occupational Hygiene.* 13: 3-5.	The medical advisor to Cape Asbestos opens with discussion about the different mineral varieties of asbestos, then notes that all "current" friction materials contain 50% chrysotile asbestos. This figure he expected to gradually decline to as little as 30%.
	1970	Hickish, D.E. and K.L. Knight. "Exposure to Asbestos During Brake Maintenance." *Annals of Occupational Hygiene.* 13: 17-21.	This paper contains data on the asbestos dust exposure of brake mechanics reported by the Medical Services of Ford of Britain. The first car servicing tests were done using Cortina and Anglia vehicles, which presumably had smaller brakes than American cars of this era. Sampling was done in the dust cloud generated by blow-out of the accumulated dust in brake drums. This yielded an average value of 2.55 fibers per cc of air. Other tests were done beside the car when the repairs were in progress, yielding somewhat lower values averaging 1.25 f/cc. Personal samples were also taken, to get the best measure of the workers' actual exposure to airborne asbestos. The average exposure during brake servicing was 0.68 f/cc. Truck brakes generated more dust. Sampling was done in an adjacent bay and two bays away from the service bay where brake repairs were performed. The values recorded were lower in these bystander locations. The bystander fiber counts ranged from 0.17 to 0.49 f/cc in the mornings, during which time only 1.5-2 hours was devoted to

Ex. #	Date	Citation	Findings
			brake cleaning. Personal sampling for mechanics doing truck brake repair showed concentrations of 7.09 f/cc, declining to 0.08 after cleaning and averaging 1.75 f/cc over the time sampling interval. The duration of this interval could easily have been adjusted to yield an average value on either side of the new British asbestos standard, 2 f/cc. Even clutch repair in the adjacent bay was recorded as 2.25 f/cc "during cleaning." Samples from bays adjacent to truck brake repair showed 0.79 f/cc as a time-averaged exposure (for cleaning and a post-cleaning combined interval). The authors conceded, "personal exposures in the vicinity (of truck brake repair) do exceed the standard." Holmes, of Turner & Newall, who found chrysotile asbestos present at up to 1% in it, analyzed brake drum dust. The authors advised safeguards during brake repairs: **"It is however recommended that care should be exercised during brake cleaning to avoid inhalation of dust produced, and the development of cleaning procedures that would reduce air contamination is desirable."** [emphasis added] They also noted that their studies did not include sampling during such procedures as "filing or grinding brake lining," but they assumed that these were hazardous processes "with the attendant need for strict precautions to prevent the inhalation of fibers."
	1970	Hatch, D. "Possible Alternatives to Asbestos as a Friction Material." *Annals of Occupational Hygiene.* 13: 25-29	Representative of Ferodo, a manufacturer. Begins with history on the development of friction products and the technical role of asbestos in the products. For brake linings the author said, "there is no substitute for asbestos which would not result in a deterioration of performance and strength." For disc brake pads the picture was brighter: "(I)t 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." On the subject of clutches, he said the spider clutch being used in the U.S. for "heavy duty manual shift gear boxes" could use asbestos-free materials such as sintered metals or ceramic-metal composites.
	1970	Bentley, M.L. "Control of the Use of Asbestos-Containing Friction Materials." *Annals of Occupational Hygiene.* 13: 31-32.	A working group of the ARC's Environmental Control Committee was devoted to friction products. Constituent members were Small and Parkes (now part of Cape Industries), Ferodo, and Mintex. "The Group (which has been formed recently) is concerned with the users of friction materials...in the replacement and service field." Bentley also said the ARC work group on friction materials was preparing "two codes of practice for users of asbestos based friction materials which will be used by (ARC). One of these is for ... the guidance of those engaged in servicing brakes and clutches." He called the codes of practice "Notes of Guidance."
	1970	Lee, G.L. "Removing Dusts from	The author worked for the auto manufacturer British Leland. He noted that a technique for cleaning brakes that would reduce dust emissions would also involve an increase in time and effort involved (hence an

Ex. #	Date	Citation	Findings
		Brake Assemblies During Vehicle Servicing Alternative Cleaning Methods." *Annals of Occupational Hygiene.* 13: 33-36.	increase in cost). He commented: "When viewed under normal lighting conditions, the result of applying a compressed-air line to remove brake dusts is very dramatic." Lee provided data (Konimeter sampling) in units one can convert for comparison with the old asbestos TLV. He showed that at the beginning of brake blow-out, there were 5000 brake dust particles per 5 cubic centimeters of air; this declined within minutes to 580 particles per 5 cc. Converting the units of these measurements to millions of particles per cubic foot of air: (1 cu. ft. 28,317 cc), 5000 particles/5cc = 28.3 Million particles/cu. ft. (MPPCF) 580 particles/5cc = 3.3 MPPCF Though it was only for brief periods of exposure that these high values were measured, it is still conceivable that the exposures would be kept high in a shop where numerous and continuous brake repairs were being done. The old TLV for asbestos exposure was 5 MPPCF, and it applied to dusts containing asbestos fibers (i.e., all particles were counted, not just the asbestos fraction of the particles). So peak exposure levels would have exceeded 5 MPPCF in brake repair although daily-average exposures were unlikely to have been that high in most shops, according to this report. For 5-minute samples *fibers* only, "...Asbestos fibers counted on membrane filter samples gave a concentration on the order of 3-5 fibers/cc." **A "modified technique" for cleaning brakes used a portable vacuum unit to extract dust raised by brushing out the brake dust with a paint brush. Damp rag wiping followed. This eliminated visible dust emissions, vastly reduced airborne particle counts, and no fibers were detected in the airborne dust samples.**
	1970	Knight, K.L. and D.IE. Hickish. "Investigations into Alternative Norms of Control for Dust Generated During the Cleaning of Brake Assemblies and Drums." *Annals of Occupational Hygiene.* 13:	Notes that when the brake dust is blown off with a compressed air hose, the dust cloud in which the operator works is "proportionate in size to the drum assembly being cleaned." Vacuum funnel and vacuum brush cleaning methods were tested. The peak exposures for both of these were way below that observed for "blow-off" -1.04 f/cc for the funnel, 0.57 f/cc for the brush, and 87 f/cc for blow-off. The vacuum brush method was preferred for its ease of use as well as the lowering of exposures.

Ex. #	Date	Citation	Findings
		37-39.	
	1970	*Asbestos.* Washington, D.C.: National Academy of Sciences, 1971, p.22	This report on asbestos air pollution notes that "an appreciable percentage (1-3%)" of the asbestos in brake linings survives the heat of friction and remains as fibrous asbestos.
	1971	Oels, H.C, *et al.* "Diffuse Malignant Mesothelioma of the Pleura: A Review of 37 Cases," *Chest* 60: 564-570.	One mesothelioma patient with a history of "probable occupational exposure to asbestos" was a "service station operator."
	April, 1972	Harwood, C.F. "Asbestos Air Pollution Resulting from the Wear of Brake Linings," Supplementary Notes Supplied to the Attendees of Seminar on Asbestos, Illinois Institute of Technology Research Institute, Chicago, pp.65-74	"(A)n estimate is presented which indicates that the asbestos emission from brake linings is significant." He assumes that 1% of brake dust is asbestos fiber, that 80% of this dust is emitted and 20% remains lodged within the brake system. This paper contains a several-page discussion, "Alternatives to Asbestos," in which sintered metals, ceramic metal, fiberglass, and sealed systems are discussed. "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 can not overcome the problems presented by the use of alternates." This was a several-day seminar attended by a number of industry representatives and the author (BC).
	June 8, 1972	Newman, B. "Perilous Particles," *Wall Street J.*	Article on asbestos begins with description of some mechanics blowing dust out of brake parts: "What the mechanics don't seem to know—like thousands of other mechanics—is that the brown dust is dangerous. And if a mechanic breathes in enough dust from worn out linings it could eventually kill him."
	1972	Moertel, C.G. "Peritoneal Mesothelioma,"	Explaining that mesothelioma is caused by asbestos, he says, "particularly vulnerable occupations are ... brake lining installation..."

Ex. #	Date	Citation	Findings
		Gastroenterology 63:346-350	
	Feb. 1973	*Control Techniques for Asbestos Air Pollutants.* Research Triangle Park, N.C.: U.S. Environmental Protection Agency Office of Air and Water Programs, pp. 3-48 and 3-49.	"In the course of servicing and overhauling motor vehicle brakes and manual clutches, the accumulated asbestos-containing dust is frequently dislodged from drums and housings by directing a compressed air jet against the deposits." Expressed concern over environmental air pollution.
	1973	Boillat, M.A. and M. Lob. "Risk of Asbestosis among Workers Replacing Brake Linings," *Schweiz. Med. Wodi.* 103:1354-1359.	English summary: "Thirty-nine workers with the job of replacing automobile brake linings (asbestos) have been investigated. The working conditions and clinical findings, including radiology and spirometric studies, are discussed. In view of the comparatively brief exposure during the working day, the maximum permissible concentration of asbestos fibers, according to the norms indicated by American health workers, does not appear to be exceeded. No cases of asbestosis were detected, but in one instance the diagnosis is open to discussion. Despite the satisfactory outcome of this study, periodic examinations of workers in this type of occupation are indicated." Subjects of the study averaged only 8 years of brake repair experience at ½ to 2 hours per day of work. Fiber concentrations from drilling holes for rivets and grinding ranged up to 29.2 f/cc; four of nine measurements exceeded 5/cc.
	May 14-18, 1973	Jacko, M.G., R.T. DuCharme, and J.I I. Somers. "Brake and Clutch Emissions Generated during Vehicle Operation." Society of Automotive	Tests of brake wear emissions from braking showed 14.4 percent of total car asbestos emissions were "retained in brake" of test vehicle. The corresponding figure for trucks was 9.2%. The overall figure for all vehicles in U.S. was 11.2% brake retention.

Ex. #	Date	Citation	Findings
		Eng. meeting, Detroit.	
	1973	Davis, J.M., and S.W. Coniam. "Experimental Studies on the Effects of Heated Chrysotile and Automobile Brake Lining Dust Injected into the Body Cavities of Mice," *Exper. Molec. Pathol.* 19:339-353.	Automobile brake lining dust was provided by' Turner & Newall from a test vehicle. The dust produced "very small granulomas and little fibrosis" when injected into the pleural cavities of mice. The study was terminated after only one year, and was sponsored by the Asbestosis Research Council. "It is planned to undertake a new series of experiments that will test the long-term effects of brake lining dust in conditions where normal chrysotile is known to produce tumors." [Davis says no such studies were done—1986.]
	1974	Greenberg, M. and T.A. Lloyd-Davies. "Mesotheliom a Register 1967-68," *Brit, J. Ind. Med.* 31:91-104.	Lists "Industry or Job Title in 167 'Definite' Mesotheliomas with Definite Occupational Exposure to Asbestos"—includes one "motor mechanic."
	Aug. 8, 1975	Lloyd, J.W. "Dear Colleague..." Hazard Alert letter, National Institute for Occupational Safety and Health, Rockville, MD.	Reports on July 21, 1975 NIOSH meeting with industry, labor, and academic attendees to discuss brake repair asbestos hazards. Data generated by the Mt. Sinai Environmental Sciences Laboratory included 1) blowout of automobile drum brakes, 2) grinding used truck brake linings, and 3) beveling new truck brake linings. "Average peak asbestos air concentrations for these three activities based on personal samples taken within 10 feet of the operation were, respectively, 10.5, 3.75, and 37.3 fibers (greater than 5 microns in length)" per cc. of air. "The present findings indicate that enough asbestos is preserved to produce significant exposures during certain brake servicing procedures." Earlier reports of mesothelioma among persons with jobs involving automobile brake servicing were cited. NIOSH estimated that 833,535 auto mechanics, 67,679 garage workers, and 6,657 (original and rebuilding) manufacturing employees made up a workforce "potentially exposed to asbestos." "Recommended (Interim) Procedures for Asbestos Brake and Clutch Servicing" were attached. These procedures included: 1) posting signs in the work area warning people not to stay there unless their work

Ex. #	Date	Citation	Findings
			required it (" ... May Cause Asbestosis and Cancer"); 2) use of industrial vacuum cleaners (with high efficiency filters) for removing dust from brakes; 3) use of respirators; 4) use of local exhaust ventilation and high efficiency dust collection on grinding machines; 5) adherence to OSHA asbestos regulations' provisions regarding special clothing and change rooms.
	Aug. 15, 1975	"HEW Warns of Asbestos Hazard in Work with Brake Linings, Spackling Mixtures," *Wall Street J.*	Summarizes the NIOSH alert notice (previous item).
	1976	Menck, H.R. and B.E. Henderson, "Occupational Differences in Rates of Lung Cancer," *J. Occup. Med.* 78:797-801.	This study on occupation and lung cancer rates in Califomia shows a statistically significant Standard Mortality Ratio (146, meaning 46 percent higher than expected) for "Auto Repair" workers. This figure is based on eight deaths from lung cancer in the years 1972-1973.
	1976	Alste, J., D. Watson, and J. Bogg. "Airborne Asbestos in the Vicinity of a Freeway," *Atmos. Environ.* 10:583-589.	Chrysotile asbestos fibers from new and worn brake linings and from the air near a freeway were examined by electron microscopy and electron diffraction. The major effect of braking appears to be in separating bundles of fibers and reducing their average length but not altering their crystal structure. The majority of particles had a maximum linear dimension of 2 microns or less.
	1976	Rohl, A.N., A.M. Langer, M.S. Wolff, and J. Weisman. "Asbestos Exposure during Brake Lining Maintenance and Repair," *Environ. Research* 72:110-128.	Unaltered chrysotile asbestos was found in garage air samples and brake drum dust. "(E)xposure of garage mechanics during brake lining maintenance and repair show that fiber concentrations frequently in excess of regulated limits are common." (Optical microscopy) Blowing out automobile brake drum dust yielded exposures of 6.6 to 29.8 f/cc with measurable exposure 50-75 feet away. Some of the other data bad been summarized in the NIOSH alert of Aug. 8, 1975. Electron microscopy showed most of the fibers were too small to be seen by optical microscopes. The authors warned that exposure to these very small and numerous asbestos fibers could have adverse effects.
	1976	Lorimer,	Tabulates exposures previously measured by others, includes their own

Ex. #	Date	Citation	Findings
		W.V. *et al.*, "Asbestos Exposure of Brake Repair Workers in the United States," *Mount Sinai J. Med.* 43:207-218.	data in great detail for all types of brake work. Clinical study of 90 men with ten or more years of brake repair work and no other history of occupational exposure to asbestos. Most of the general mechanics examined did brake lining more than once weekly. Parenchymal fibrosis was seen on X-ray in 18 (20%) and pleural thickening in 5 (6%). Those who started work before 1946 had twice the prevalence of abnormal X-rays as those starting in 1946-1955. One quarter of the workers had restrictive pulmonary function test findings. "(T)he findings suggest that asbestos disease will be present among (brake maintenance) workers and that appropriate control measures should be urgently instituted."
	1977	Rohl, A.N. *et al.*, "Asbestos Content of Dust Encountered in Brake Maintenance and Repair," *Proc. Roy. Soc. Med.* 70:32-37.	Another report from the Mt. Sinai group on the presence of chrysotile asbestos in brake drum dust from all over the world, the submicroscopic size of most of the asbestos fibers, and comparison of brake mechanics' asbestos exposure with OSHA standards (optical microscopy.). Authors call for implementation of industrial hygiene practices and for epidemiological mortality studies of garage mechanics.
	1977	Bruckman, L., R.A. Rubine, and B. Christine. "Asbestos and Mesothelioma Incidence in Connecticut," *J. Air Pollut. Contr. Assoc.* 27:121-126.	Reports a case of mesothelioma in a toll booth operator. These investigators found increased asbestos exposure at toll booths compared to ambient air of Connecticut cities.
	1978	Seshan, K. "On the utility of dark-field electron microscopy in the determination of the degree of deformation in Chrysotile Asbestos: An Environmenta l Research	New technique of analysis verifies that "chrysotile asbestos in various stages of deformation" survives in brake drum dust.

Ex. #	Date	Citation	Findings
		Application" *Environ. Research* 16:383-392.	
	1978	Rohl, A.N., A.M. Langer, and I.J. Selikoff. "Airborne Asbestos in the Vicinity of a Freeway," *Atmos. Environ.*12:2030-2031.	Adds a number of unpublished reports confirming the presence of chrysotile in disintegrated brake linings from Great Britain (F. Pooley), France (P. Sebastien), and South Africa (M.S. Kikine). Refers to findings of asbestosis among automotive maintenance workers.
	Oct. 1978	"Friction Materials Work Practices Guide." Friction Materials Standards Institute, Paramus, N.J. 12 pp.	"When removing worn friction materials remove the accumulated dust in the assembly with an industrial vacuum cleaner equipped with a high efficiency filter system. If such equipment is not available, dust can be removed with a damp cloth. Do not use compressed air or dry brushing for cleaning. Use a NIOSH approved respirator when removing worn friction materials, or cleaning brake or clutch assemblies." Local exhaust ventilation is recommended for machining of friction materials. Machining and repair areas "should be isolated from other work areas in a restricted area to prevent unnecessary exposure of other workers." Warning signs are suggested to limit access to brake work areas. "Work clothing should not be taken home." The industry trade group also covers disposal of vacuum cleaner waste in marked, impermeable bags in this pamphlet.
	1979	Kagan, E. *et al.* "Asbestos-Associated Neoplasms of 13 Cell Lineage," *Amer. J. Med.* 67:325-330.	Reports one case of pleural mesothelioma in a man who had installed automotive brake linings for 25 years.
	1983	Kagan, E., and R.J. Jacobson. "Lymphoid and Plasma Cell Malignancies: Asbestos-related	Reports one case of pleural mesothelioma in a man who had installed automotive brake linings for 25 years.

Ex. #	Date	Citation	Findings
		Disorders of Long Latency," *Amer. J. Clin. Path.* 80:14-20.	
	1979	de Lajartre, M. and A.Y. de Lajartre. "Mesotheliom a on the Coast of Brittany, France," *Ann.* N.Y. *Acad. Sci.* 330:323-332.	"Certain" occupational exposure to asbestos was identified in 51 cases of mesothelioma, including 4 "mechanics." Exposure characterized as "probable" for 6 "construction mechanics."
	1980	McDonald, A.D. and J.C. McDonald. "Malignant Mesothelioma in North America," *Cancer* 46:1650-1656.	A review of mesothelioma cases included 11 with occupational histories of garage work. A series of matched controls without mesothelioma included 12 with such histories. Individuals with histories of asbestos mining and manufacturing, or construction and shipyard work in addition to garage work were not counted as garage workers.
	June, 1981	Selikoff, I.J. et al. Disability Compensation for Asbestos-Associated Disease in the United States, U.S. Dept. of Labor Contract No. J-9-M-8-0165.	Projects a risk of asbestos cancer for a number of occupations compared with insulation work. "Automobile maintenance" is estimated to carry 4% as much risk as insulation work. Projected number of deaths from asbestos-related cancer among automobile maintenance workers estimated to be rising steeply, from 400/year in 1983 to a peak of 500-600/year during the years 1990-2015. Quotes Weston as saying that 900,000 workers are continually exposed and 1,070,000 are exposed occasionally or infrequently.
	1982	Nicholson, W.J., G. Perkel, and I.J. Selikoff. "Occupational Exposure to Asbestos: Population at Risk and	Similar to analysis in Selikoff et al (above).

Ex. #	Date	Citation	Findings
		Projected Mortality' 1980-2030," *Amer. J. Indust. Med.* 3:259-311.	
	1982	Roberts, D.R., and R.D. Zumwalde. "Industrial Hygiene Summary Report of Asbestos Exposure Assessment for Brake Mechanics." NIOSH Report #32.4, Cincinnati.	Time-weighted average exposures for mechanics using various brake repair techniques were generally in the range of 0.1 to 0.3 f/cc. General area air samples were 0.01-0.13 f/cc.
	Nov. 13, 1982	Langer, AM. and W.T.E. McCaughey. "Mesotheliom a in a Brake Repair Worker," *Lancet* 1101-1102.	Finds asbestos fibers in the lung tissue of a mesothelioma patient whose occupational exposure consisted of many years of brake servicing work.
	1983	Glickman, L.F., *et al.* "Mesotheliom a in Pet Dogs Associated with Exposure of Their Owners to Asbestos," *Environ. Res.* 32:305-313.	Over a five-year period, 15 pet dogs were diagnosed with mesothelioma at a veterinary hospital. The owners of 2 were car and truck mechanics by occupation, and the hobby of a third was automobile servicing. Two of the other dogs' owners were an automobile body repairer and a used automobile parts supply worker.
	1983	Mancuso, T.F., "Mesotheliom a Among Machinists in Railroad and Other	Report of pleural mesothelioma in an automechanic.

Ex. #	Date	Citation	Findings
		Industries," *Amer. J. Indust. Med.* 4:501-513.	
	Feb. 1985	"Asbestos Fact Book." U.S. Environmental Protection Agency, 11 pp.	"(P)eople who work directly on brake maintenance are widely exposed to exceptionally high levels of asbestos. This occurs when brakes are cleaned and serviced during routine maintenance activities. EPA is establishing a Brake Mechanics Program to provide information and education on asbestos problems to vocational/technical students, working mechanics, and brake repair and maintenance specialists. The program will alert these specialists to the presence of asbestos in brakes and to methods that will minimize the release of asbestos fiber into the workplace."

Commercial Substitution of Asbestos in Friction Products

Ex. #	Date	Citation	Findings
	Sept. 1976	"ICI Asbestos-Free Brake Shoe," *Asbestos* 12-14.	Announces immediate production and worldwide marketing of a railroad brake shoe that contains no lead or asbestos. Called Tiger, the product was developed by Abex Corporation, subsidiary of IC Industries, Inc.
	1976	Kwolek, J.P. "Friction Materials for Small Car Solid Rotor Applications," *SAE Transactions,* paper no.750874.	Gives history of development of semi-metallic brakes, starting with their use in police cars, taxicabs, and "a few vehicles sold to the general public." Notes that semi-metallic front disc brakes achieved success in meeting standards of the Los Angeles Police Department, and displayed a number of advantages over conventional asbestos-organic brake compositions by 1970. Increased cost was a major obstacle to widespread usage at that time. Author worked for Bendix Corporation.
	1976	*Annual Report,* Raybestos-Manhattan, Inc.	"The escalating costs associated with handling this raw material and the uncertain consequences of future government asbestos regulations ... have necessitated our decision to work toward the elimination of asbestos from all our friction products and this eventuality has become an essential part of our long term product and manufacturing plans."
	1978	*Annual Report,* Raybestos-Manhattan, Inc.	"Although from a social and political standpoint, publicity concerning asbestos has not adversely affected our business nor do we expect it to in the near future ... from a long-range standpoint, we are planning to eliminate asbestos from our friction materials products by 1982 in order to minimize the effect of any further government regulations in this area."
	1980	Castleman, B.I. and M.J. Vera. "Impending Proliferation of Asbestos," *Intenat. J. Health Serv.* 10:389-403.	Paraphrases a communication from General Motors to the U.S. Environmental Protection Agency (Sept. 7, 1979), called "General Motors Programs on Non-Asbestos Friction Materials for Brake Systems." Approximately 60 percent of all passenger car disc brakes manufactured and used by G.M. had non-asbestos friction materials in 1979. G.M. projected that all its 1983-model passenger cars with disc brakes would have asbestos-free brakes, and all cars with drum brakes and light trucks would have asbestos-free brakes by the 1985 model year.
	July, 1981	Norman, J.C. "Synthetic Fibers Find Applications in Transportation," *Indust. Research and Development.*	DuPont marketing specialist for "Kevlar" aramid fiber presents test results and describes performance of this product as an asbestos substitute in brakes. Cost of use initially higher, but longer service life expected to offset the 25 percent initial cost premium in the life-cycle cost of the product. Excels in heavy-duty applications, compared with conventional asbestos brakes.

Control Technology for Brake and Clutch Work

Ex. #	Date	Citation	Findings
	1978	National Loss Control Service Corp., Long Grove, IL 60049. *Report of Industrial Hygiene Study for Ammco Tools, Inc. North Chicago, IL.*	A 15-minute exposure peak of 1.1 f/cc was found with brake washing using the Ammco Model 1250 brake assembly washer after use of a hammer. A "poorly maintained" Model 880 created operator exposures during grinding of 1.4 f/cc, but the "well maintained" Model 880 also created operator exposure of 1.4 f/cc for grinding brake linings. This system uses a solvent, which dries into a gel in the collection tray, trapping the fibers, according to verbal communication from the manufacturer. Nonetheless, measured asbestos levels using optical microscopy are excessive and allow shop contamination to occur.
	1980	*Asbestos Product Test Results.* GCA Corp., Bedford, MA 01730. Prepared for the U.S. Environmenta l Protection Agency, Office of Pesticides and Toxic Substances.	Widespread garage contamination is illustrated by worker exposure measurements during compressed air use of 0.85 f/cc with levels of 0.1 f/cc 25 feet away. When the mechanic removed the brake housing and cleaned it by repeatedly striking it with a hammer, his 14-minute exposure was measured as 1.29 f/cc. In these tests, a scanning electron microscope was used to analyze tile air samples, so this would not be comparable to measurements using conventional optical techniques.
	July 22, 1985	*Asbestos Dust Control in Brake Maintenance.* PEI Associates, Inc., P.O. Box 46100, Cincinnati, OH 45246. Prepared for the U.S. Environmenta l Protection Agency, Office of Pesticides and Toxic Substances	This report reviews exposures with a variety of improvised control techniques which have emerged as alternatives to the compressed air hose. Their performance was generally poor: damp rag use permitted peak asbestos exposures up to 2.6 f/cc with time-weighted averages (TWAs) up to 0.28; a liquid squirt bottle created a 10-minute peak of 0.54 f/cc with TWA over five hours of 0.21; the use of stoddard solvent flowing through an air gun caused peak levels up to 0.68 f/cc and TWAs slightly under 0.1; dry rag and brush generated peaks up to 0.81 f/cc with TWAs up to 0.2. Wetting methods not using a collection system simply disperse the fibers, and when the liquid dries, fibers remain in the shop ready to enter the room air with minimal motion. Background contamination from such methods, therefore, would not necessarily be less than with the compressed-air cleaning method. A wet method system with a collection tray was also evaluated (Ammco Brake Assembly Washer). Unfortunately, 15-minute peaks were 1.1 f/cc.

Case Reports of Mesothelioma in Brake Repair Work

Ex. #	Date	Citation	Findings
	1982	Langer and McCaughey *(Lancet,* 1982).	Case report of mesothelioma in a brake repair worker.
	1989	E.S. Hansen, "Mortality of Auto Mechanics." *Scand. J. Work Environ. Health* 15.43-46.	Case report of mesothelioma in a brake repair worker.