ASBESTOS DUST CONTROL IN BRAKE MAINTENANCE

by

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

As part of a mechanics' awareness and education program, the Office of Toxic Substances of the U.S. Environmental Protection Agency is assessing the potential risks associated with release of asbestos dust during brake maintenance. Mechanics often clean dust from the brake assembly with a dry rag, brush, or compressed air gun. Such techniques offer no protection from asbestos exposure. To reduce exposure, some mechanics use a shop vacuum, damp rag, or water hose to remove the dust. There are also a number of products sold specifically to reduce mechanics' exposure to asbestos; these include enclosure systems vented to a high-efficiency particulate air (HEPA) filter and amended water wash systems. The purpose of this task was to identify existing controls and procedures used to limit worker exposure to asbestos during brake maintenance and to quantify exposures using existing monitoring data.

1.2 APPROACH

The primary sources of information for this study were direct contact with vendors and users of control equipment, literature and test data supplied by the vendors, and the open literature. Other sources included general references on asbestos, contacts with persons familiar with asbestos exposure in general, and reports on asbestos brake manufacture from the National Institute for Occupational Safety and Health (NIOSH). Worker comments were also solicited through telephone contacts with facilities using control systems.

1.3 ORGANIZATION AND CONTENTS

Section 2 presents a general description of the problem and explains how asbestos exposure from brake dust differs from other asbestos exposures. Section 3 describes in detail the techniques and control systems identified by PEI. Section 4 discusses the control effectiveness of the techniques or controls. Section 5 presents conclusions and recommendations. Appendix A presents vendor literature on several control systems.

SECTION 2

BRAKE DUST CHARACTERISTICS

Asbestos fibers may be released to the air whenever a mechanic works on a brake drum assembly. The characteristics of the asbestos in the brake dust differ significantly from both other asbestos exposures and from the asbestos used to make the brake linings, however. The fibers, which represent only a small fraction of the asbestos present in the original brake linings, are much shorter than those from other sources.

The wearing of brake shoes is due to five different types of wear:

- Abrasion;
- Heat;
- Adhesion;
- Fatigue; and
- Macroshear.

Abrasive wear is caused by either two surfaces interfacing (the rotor and the pad) or by foreign particles such as sand, clay, mud or salt caught between the two surfaces. The amount of wear increases with temperature, braking load, and the concentration, size, and hardness of foreign particles.

Thermal wear includes physical and chemical reactions caused by high temperatures. The reactions include pyrolysis, oxidation, thermoparticulation, explosion, melting, evaporation and sublimation. The amount of wear increases exponentially with temperature.

Adhesive wear involves the adhesion of organic or inorganic materials to the rotor and subsequent tearing or separation of the material from the pad. Adhesive wear increases with temperature, braking load, and the concentration of the adherent component.

Fatigue wear can be caused by repeated heating and cooling, as a result of a single abusive thermal loading, or by repeated mechanical stressing. This wear increases with extreme temperature changes, drums that are out-of-round, discs out-of-parallel, or if the rotor thickness is not uniform.

Macroshear wear causes fracture of the brake pad from heavy loading. The pad weakened by heat, oxidation, or other mechanisms shears away by a single heavy brake application. The fragments of the sheared ad can cause further abrasive damage if caught in the interface between the pad and the rotor.

Most vehicles are subject primarily to abrasive and adhesive wear. Below 450°F, abrasive and adhesive wear are predominant, while above 450°F thermal wear is predominant.[1] The percentage of asbestos in the final brake dust depends on the type of braking the vehicle has been subjected to during the lifetime of the brake shoes.

The emission of asbestos from brake shoes is not a simple relationship. Emissions per mile and composition of the dust are dependent on the following:[2]

- Composition of the friction material,
- Composition, metallurgical structure and hardness of the cast iron rotor (drum or disc),
- Surface roughness of the rotor,
- Previous use of the friction material - primarily thermal history - both recent and overall,
- Third-body contamination of the sliding interface by road dust, wear debris, rain water, salt and the like,
- Vehicle usage - miles driven (urban, suburban, rural, expressway),
- Vehicle weight including passengers and cargo,
- Vehicle speed at beginning and end of the stop,
- Deceleration (average and instantaneous),
- Frequency of braking due to traffic, terrain, and driver habits,
- Interface temperature, sliding speed, and unit load on the friction material,
- Roadway surface and grade,
- Air temperature, wind velocity, and wind direction relative to vehicle motion,
- Brake design, including brake balance front to rear, and swept area in relation to vehicle weight and horsepower,

- Vehicle design including brake cooling adequacy,
- Operator habits and behavior,
- Brake adjustment and maintenance,
- Type of tires,
- Engine-transmission braking,
- Suspension system, and
- Aerodynamic shape of the vehicle.

Chrysotile asbestos, which comprises 40 to 60 percent of the original brake shoe, is a major component of unused brake shoes.[2] A study by the General Motors Research Laboratory reported tests showing that over 99.9 percent of the mass of original asbestos fibers was broken down into non-fibrous magnesium silicates. The same study estimated that at a stopping rate of 1.2 stops per kilometer, that 2.6 µg of asbestos/km is emitted to the air, 0.76 µg/km settles on the roadway, and 2.2 µg/km is entrained in the wheel.[2] The emitted particles averaged 0.029 percent asbestos.[2] Both optical microscopy and electron microscopy methods were used in this study.

This breakdown of the asbestos to non-fibrous forms is due to the chemistry of asbestos itself. Asbestos occurs in the fibrous form due to crystallization of the hydrated mineral in the form of long, strong, flexible fibers.[3] Heat during brake use releases the water of hydration, thus breaking the fibrous form. The crystals begin losing water at about 700°F. More water is lost at around 1170°F, with complete breakdown to olivine powder at 1520°F.[1]

There is some evidence to suggest that the morphology and size of the fiber, regardless of the fiber type, are responsible for its carcinogenicity.[4] These studies tend to suggest that the size dimensions are more important than chemical and surface characteristics in inducing a biological effect.[4]

Studies reviewed by PEI showed brake dust contains from 0.004 to 30 percent asbestos by weight, with the vast majority of the samples under 5 percent asbestos.[2,5,6,7,8] In all five studies total fibers were measured rather than just fibers greater than 5 µm in length. The majority of the asbestos (75 percent of the fibers in one study) is less than 5 µm in

length.[7,8] The median length in another study was 0.5 μm.[2] It should be noted that both the OSHA standard of 2 f/cc, (8-hour TWA) and the NIOSH recommended standard of 0.1 f/cc (8-hour TWA) are only for fibers greater than 5 μm in length.[9]

In conclusion, for most samples of brake dust, asbestos makes up only a small percentage of the dust and the fibers are shorter than those for other asbestos exposures. These points are important in judging the effectiveness of a monitoring test method, assessing the effectiveness of a control device, and determining harmful health effects.

SECTION 3

TECHNIQUES AND SYSTEMS TO LOWER WORKER EXPOSURE

This section describes the various techniques and systems used by mechanics in brake maintenance. NIOSH estimates that a workforce of 151,000 brake mechanics and garage workers in the U.S. are potentially exposed to asbestos.[4]

3.1 TECHNIQUES USED BY MECHANICS TO REMOVE DUST

Several techniques have traditionally been used by mechanics to remove brake dust and accumulated dirt and grease. Reduction in asbestos exposure has not always been a primary consideration.

3.1.1 Compressed Air Gun Blowing

One of the simplest methods for removing brake dust is blowing with a compressed air gun. This was once used almost universally, and is still widely used. In an appendix to Reference 4, NIOSH recommends that "Under no circumstances shall compressed air... be used for cleaning." It is important to note that this method does not dispose of the fibers, but merely displaces them into the mechanic's breathing zone or into the work area where they are available for later reentrainment.

3.1.2 Brush or Dry Rag

In this technique the mechanic removes the dust using a dry brush or rag. While not as much dust is entrained as with air blowing, the dust stands more of a chance of falling on the worker's clothing and in the immediate area. NIOSH again recommends that "Under no circumstances shall... a dry brush be used for cleaning."[4] Although the method could lend itself to collection and disposal of the dust, this is likely often not the case. If the dust is not collected, it will remain in the workplace available for later reentrainment. The method is highly dependent on the worker's technique. For example, if extreme care is taken and asbestos-containing dust is

wiped from the brush or rag into a container for disposal, worker exposure should be considerably lower than for compressed air blowing. If, however, the dust is brushed onto the floor or the worker's clothing, or if the rag is used for other tasks, the exposure could be comparable to exposures caused by compressed air blowing.

3.1.3 Damp Brush or Rag

Some mechanics wet the brush or rag prior to cleaning the brake. The quantity of water must be sufficient to wet the dust. When the water dries, the asbestos will again be available for reentrainment, however, and the asbestos will remain in the workplace available for later reentrainment. Although it seems logical that wetting a brush would reduce the asbestos exposure, the literature suggests that the technique of the individual worker is more important than the presence or absence of a relatively small amount of water.

3.1.4 Water Hose

Soaking the brake assembly with a hose has several advantages over the use of damp brushes or rags. First, sufficient water is supplied to assure complete wetting of all the asbestos dust. Second, the hose can be used to further wash the dust from the garage floor to a floor drain. Finally, there is little likelihood that the dust will fall on the mechanic's clothing, as the worker would try to not get wet and in the process avoid the asbestos. Disadvantages of this method include the disposal of asbestos down the sewer and the chance that the dust would not be washed down the drain and become available for reentrainment.

3.1.5 Brake Cleaner as a Wetting Agent

Although brake cleaners are primarily used to remove grease and dirt from the brake housing, several contacts mentioned their use to also control asbestos exposure. Most typical commercial brake cleaners contain a solvent, generally 1,1,1-trichloroethane, in an aerosol container. It is also possible to mix the solvent into a compressed air system and spray it on the brake housing.[4] It is important that the solvent be collected for recycle. If this is not done, and the solvent is allowed to evaporate, the asbestos becomes available for reentrainment. From an asbestos control standpoint,

the use of a solvent has no advantage over the use of water. The aerosol blast could displace the brake dust. Because brake cleaner solvents evaporate quickly, subsequent exposures could occur later upon reentrainment.

3.1.6 Shop Vacuum

Anecdotal evidence indicate limited use of shop vacuums to remove brake dust. Due to the small size of the asbestos fibers in brake dust, it is likely that very little asbestos is caught in the vacuum filter. Exposures could be high and should relate primarily to the placement of the vacuum exhaust. This technique has no advantages over other methods and may well give the mechanic a false sense of safety.

3.2 SYSTEMS SOLD TO LOWER ASBESTOS EXPOSURE

There are several types of enclosures and other systems being marketed to mechanics to control exposure to asbestos during brake maintenance. Appendix A presents vendor literature on these systems.

3.2.1 Ammco Brake Assembly Washer Model 1250[10]

The Ammco brake assembly washer consists of two pans mounted vertically and connected to a standard mechanic's compressed air gun. The top pan is perforated to allow fluid to flow through, and the bottom pan acts as a sump for the liquid. Ammco recommends the use of amended water (i.e., water containing a surfactant) in the system and sells packets of concentrate to mix with the water. Gasoline or flammable solvents should not be used in the system.

Liquid is siphoned from the lower pan into the air line at standard air gun line pressure. This lowers the pressure to 6 to 8 pounds, emitting a light spray. The liquid runs off the part into the upper, perforated pan which catches parts and large debris. The liquid drains into the lower pan for recycle. Non-flammable solvents used in the system may or may not be reclaimed. Amended water is disposed of down a sanitary sewer. If the amended water used in the brake washer system is disposed of down a sewer it would contain all of the asbestos removed from the brakes. Since the exposure of concern with asbestos is inhalation and retention in the lungs, there

is little or no chance of further human exposure of this type from the asbestos in the waste water.

The vendor reported use by Sears, Midas, and General Motors. Calls to outlets of these retailers in the Cincinnati area identified two locations that had the equipment; neither, however, was using the system as intended. Both were using it instead as a parts washer and felt that they no longer needed to use it as intended for asbestos control because they no longer were installing any brake pads that contained asbestos.

The cost of the washer system is $252; 20 packets of amending agent concentrate costs $17.50.

3.2.2 Clayton Associates, Inc., Brake Cleaning Equipment[11]

The Clayton Associates brake cleaning equipment consists of a transparent enclosure, available in two sizes, that surrounds the brake drum. The Clayton unit has glove inserts for the worker's hands. The asbestos-containing dust is blown using a standard air gun, and the enclosure is vented to a HEPA filter at 246 CFM. The Clayton system claims to be superior to other enclosure systems in lowering worker exposure during filter changes on the vacuum.

Tests by Mount Sinai Medical Center show virtual elimination of asbestos exposure when this system is used as directed. The vendor knew of no Clayton systems in use in the Cincinnati or Dayton areas.[8]

The cost of a complete 1000 series system for autos and light trucks is $3,000; the 2000 series size for commercial vehicles costs $3,100. These prices are discounted from list, but represent typical actual purchase prices.

3.2.3 Hako Minuteman Asbestos Brake Drum Vacuum System[11]

The Hako Minuteman vacuum system consists of a clear, flexible vinyl enclosure, available in two sizes, held in place by a wire frame. The asbestos-containing dust is blown using a standard air gun, and the enclosure is vented to a HEPA filter at 95 CFM. The vendor knew of no Hako units being used in the Cincinnati or Dayton areas and could identify no tests of the system.

The cost of a Hako system ranges between $1,100 and $1,600 depending upon its size.

3.2.4 Nilfisk Asbesto-Clene System[12]

The Nilfisk Asbesto-Clene system consists of a transparent enclosure cylinder available in three sizes to fit vehicles from passenger cars to large commercial vehicles. The asbestos-containing dust is blown using a standard air gun, and the enclosure is vented to a HEPA filter.

Tests by Mount Sinai Medical Center show virtual elimination of asbestos exposure when this system is used as directed.[7] Cincinnati Bell has used the Nilfisk system for about six years, but has discontinued use of the enclosure portion. The company uses the vacuum portion to remove the dust rather than blowing with an air gun. It claims to have run tests indicating that this approach provided the same worker protection, was less cumbersome for the mechanic, and lessened contamination due to build-ups inside the enclosure. The company also claimed that if the vacuum in the original system were not adjusted properly, air and dust could escape during blowing. They felt that this was because under some conditions the volume of air from the air gun could exceed the air exhausted through the vacuum, thus causing a positive pressure in the enclosure for a short period. One vendor indicated that this could happen with a competitor's product due to a poor seal and an undersized vacuum.

The cost of the 400 size system, the smallest, is $1,536; the 500 system, $1,810; and the 600 system, $4,429.

3.2.5 HEPA Filtered Vacuum

No vendor is marketing a HEPA filtered vacuum as a brake maintenance system but, as noted above, at least one garage contacted is using the Nilfisk system in this manner. The user claims that monitoring indicates equivalent exposure to that measured when using the complete enclosure and vacuum system. In addition, the use of the vacuum to remove dust has the added advantage of no compressed air blowing, increased mechanic mobility, and lower cost. In addition, because the vacuum would not have to evacuate air generated by the air gun, the vacuum could be designed smaller and therefore sold at a lower cost. The cost of a vacuum with a HEPA filter ranges from $800 to $1,100 depending on the size of the system.

3.2.6 Other Systems

There are likely a number of other enclosure and wash systems being marketed. As an example, Control Resources Systems, Inc. has a system called Brakemaster that sells for $1,749. Vendor literature on this system was promised but has not yet been received by PEI.

3.3 PERSONAL PROTECTIVE EQUIPMENT

There are two types of air-purifying respirators generally used by mechanics that protect against asbestos: single-use disposable masks and reusable twin-cartridge respirators. Single-use disposable respirators are less expensive than twin-cartridge respirators and cartridges, but the masks must be discarded after use. Twin-cartridge respirators may be used many times, but the cartridges must be replaced periodically and the facepiece requires regular maintenance and cleaning. Table 3-1 presents the prices for both types of respirators. Several manufacturer's prices are given to represent a range of prices.

TABLE 3-1. PERSONAL PROTECTIVE MASKS

Mask type	Company	Product No.	Cost per respirator, 1985 dollars
Single use disposable	3M	8710	0.93
	North Safety Equipment	7170	3.56
	AO	1070	0.92
Reusable, twin cartridge, half mask	MSA	463873	13.60
	AO	50442 S4000	14.70
	3M	7200	11.15
Reusable, twin cartridge, full mask	MSA	471288	96.50
	AO	50367 S7000	89.00
	Scott	652-6	72.85
Cartridge filters	MSA	464035	6.62
	3M[a]	7255	6.55
	AO	51037 R57A	7.60

[a] This filter requires a reusable cartridge retainer costing $0.50.

SECTION 4

CONTROL EFFECTIVENESS

This section summarizes available monitoring data which can be used to evaluate the effectiveness of various abestos control methods during brake maintenance. Because this monitoring was done under a variety of sampling times and conditions, with variable amounts of brake drum dust, and variable asbestos concentrations in the dust, and by different test methods, the results should be viewed only as rough estimates of worker exposure. Table 4-1 summarizes the available personal monitoring data for each technique. Area monitoring was performed at greatly varying distances from the work area and at different exposures to the air gun used and is therefore an inconsistent measure of exposure. Appendix B presents a summary of analytical methods for asbestos.

4.1 EFFECTIVENESS IN LOWERING ASBESTOS EXPOSURE

An average exposure for each facility was determined by calculating a geometric mean of the individual personal monitoring values.

4.1.1 Compressed Air Gun Blowing

Facility G, Reference 4, is an automobile brake service shop also doing front-end alignment and shock absorber service. The normal work week was five 9-hour days and one 6-hour day. Three service stalls were used by three full time employees. Four to six brake jobs were done per week at the shop. Five peak measurements on one mechanic ranged from 0.14 to 2.69 f/cc, with typical sample time of 30 seconds. One TWA was given of 0.03 f/cc for approximately a 6-hour sample. The geometric mean of the peak data is 0.71 f/cc. The optical microscopy fiber count method was used for all samples.

TABLE 4-1. AVAILABLE MONITORING DATA BY CONTROL TECHNIQUE

Technique or system	Facility	Measured exposures f/cc		
		Range of peak values	Mean peak	Mean TWA
Compressed air gun	G, Ref 4	0.14 - 2.69	0.71	0.03
	I, Ref 4	0.91 - 15.00	4.87	0.13
	Ref 5	6.6 - 29.8	16.00	-
	Ref 13	0.85	0.85	-
	Ref 17	0.33	0.33	0.04
	Ref 18	0.6 - 3.00	1.43	-
Dry brush or rag	D, Ref 4	0.61 - 0.81	0.70	0.19
	Ref 5	1.3 - 3.6	2.5	-
	Total	0.70 - 2.5	1.6	0.19
Damp brush or rag	C, Ref 4	0.67 - 2.62	1.4	0.25
Water hose	B, Ref 4	0.54[a]	0.54[a]	0.21[a]
Brake cleaner/aerosol	O	N/A[b]	N/A	N/A
Brake cleaner/compressed air	I, Ref 4	0.25 - 0.68	0.41	0.07
Vacuum/shop vacuum	O	N/A	N/A	N/A
Ammco Brake assembly, washer model 1250	Ref 14	0.53 - 1.1	0.76	0.03[c]
Clayton Associates, Inc. brake cleaning equipment	Ref 8	0.0	0.0	N/A
Hako Minuteman vacuum system	O	N/A	N/A	N/A
Nilfisk Asbesto-Clene system	Ref 7	0.0 - 0.5	0.0	N/A
Vacuum/HEPA filter	O	N/A	N/A	N/A

[a] Measurement is for a liquid, squirt bottle. It is assumed that use of a hose would result in lower exposure

[b] N/A = Not available.

[c] Assumes 1 brake job per day.

Facility I, Reference 4, is a large automobile brake service shop also doing front-end alignment and shock absorber service. Five full time mechanics used 4 service stalls, 9 hours per day, 6 days per week. The shop performed 35 to 45 brake repair jobs per week. Four peak measurements on three mechanics ranged from 0.91 to 15.00 f/cc, with typical sample times of 45 seconds. Three TWA's ranged from 0.10 to 0.19 f/cc over an average 4.5 hour sample period. The geometric mean of the peak data is 4.87 f/cc. The optical microscopy fiber count method was used for all samples.

Reference 5 presents a summary of personal air sampling carried out at franchised auto dealer garages, tank fleet repair shops, and a municipal truck repair shop. Four samples were taken, with results ranging from 6.6 to 29.8 f/cc, with a mean of 16.0 f/cc. Samples averaged 5 minutes in duration during the period of blowing with compressed air. The optical microscopy fiber count methods was used for all samples.

Reference 13 presents one sample of worker exposure during the cleaning of a brake housing with compressed air. The 13-minute sample result was 0.85 f/cc; scanning electron microscopy was used to count and size the fibers.

Reference 17 presents both a TWA and a peak measurement taken at a brake and alignment service shop while changing the brakes of a 1971 Vega. The measurement was for fibers greater than 5 microns only with a TWA of 0.04 f/cc and a peak one minute measurement of 0.33 f/cc during use of the compressed air gun. Optical microscopy was the measurement method used.

Reference 18 represents an automobile brake servicing operation in a city maintenance garage. Five samples for blowing-off of brake drums ranged from 0.6 f/cc to 3.0 f/cc with a mean of 1.43 f/cc. The sample times were not given and measurements were for fibers greater than 5 microns and both x-ray diffraction and optical microscopy methods were used.

Other sources gave measurements ranging from 0.07 to 30.0 f/cc; the sources did not provide enough information to avoid possible problems in combining the data, however.[15,16]

4.1.2 Dry Brush or Rag

Facility D, Reference 4, is a municipal garage where an average of eight brake jobs per day were performed on cars or trucks by any one of 60 mechanics. The hours of operation were 8 hours per day, 5 days per week. Two peak

measurements on two mechanics were 0.61 and 0.81 f/cc, for an average 15-minute sample. .Two TWA measurements were 0.19 and 0.20 f/cc, with a geometric mean of 0.19 f/cc. The geometric mean of the peak data is 0.70 f/cc. The optical microscopy fiber count method was used.

Reference 5 presents a summary of personal air sampling carried out at franchised auto dealer garages, taxi fleet repair shops, and a municipal truck repair shop. Two samples ranged from 1.3 to 3.6 f/cc, with a mean of 2.5 f/cc. Samples averaged 5 minutes during cleaning of the brake drum with a dry brush. The optical microscopy fiber count method was used for all samples.

An arithmetic mean of the two facilities showed a peak of 1.6 f/cc and a TWA of 0.19 f/cc.

4.1.3 Damp Brush or Rag

Facility C, Reference 4, is a municipal garage that averages one complete brake job per day, taking about 5 hours per job. There were five employees responsible for brake servicing and the facility operated 8 hours per day, 5 days per week. Four peak measurements on three mechanics ranged from 0.67 to 2.62 f/cc with typical sample times of 5 minutes. Three TWA's ranged from 0.23 to 0.28 f/cc, with typical sample times of 5 hours. The geometric mean of the peak data is 1.36 f/cc. The optical microscopy fiber count method was used.

4.1.4 Water Hose

No data were found measuring exposure for this method, however, one facility in Reference 4 used a liquid squirt bottle to wash down the brake housing. Facility B, Reference 4, is a municipal garage employing six mechanics and operating 8 hours per day, 5 days per week. Only one peak measurement for use of a liquid squirt bottle of 0.54 f/cc (10 minute) and one TWA of 0.21 f/cc (5.5 hours) was measured. The optical microscopy fiber count method was used. Use of a hose would likely improve the control over that of the use of a squirt bottle.

4.1.5 Brake Cleaner as a Wetting Agent

Facility I, Reference 4, a brake service shop described in Section 4.1.1, had four measurements for two mechanics for the use of Stoddard sol-

vent siphoned through an air gun. The peak measurements ranged from 0.25 to 0.68 f/cc, with a typical sample time of 45 seconds. Two TWA's ranged from 0.07 to 0.08 f/cc for a typical 4 hour sample. The geometric mean of the peak data is 0.41 f/cc. The optical microscopy fiber count method was used.

4.1.6 Shop Vacuum

No tests were found to estimate exposure using this technique.

4.1.7 Ammco Brake Assembly Washer Model 1250

Two tests were supplied by the vendor.[14] They involved detaching 4 tires from an old car, knocking corrosion off the wheels with a hammer, taking the wheel covers off, and washing the brake housings with the washer and concentrate. Both samples were taken at the same location at the same time. A 15-minute sample showed 1.1 f/cc, while a 30-minute sample indicated 0.53 f/cc. A geometric mean of 0.76 f/cc was calculated. The phase contrast microscopy technique was used.

4.1.8 Clayton Associates, Inc., Brake Cleaning Equipment

Five tests supplied by the vendor showed 0.0 f/cc for all samples by optical microscopy.[8] One sample taken on the mechanic prior to the tests showed 215 ng/m³ by electron microscopy, indicating there was asbestos in the area from previous work.

4.1.9 Hako Minuteman Asbestos Brake Drum Vacuum System

No tests were found indicating worker exposure during use of the Hako system.

4.1.10 Nilfisk Asbestos-Clene System

The vendor supplied three tests at one facility. The tests showed some background asbestos contamination 70 feet from the operation. Tests on the mechanic ranged from 0.0 to 0.5 f/cc. On the test indicating 0.5 f/cc, the mechanic had worked on a brake job without using the Nilfisk system and did not change his clothes. On the other tests, mechanics wore clean overalls. For this reason, the mean of the tests for this control is calculated as 0.0 f/cc and does not include the test with the contaminated overalls. The tests cited here were optical microscopy, but electron microscopy tests were also run.

4.1.11 HEPA Filter Vacuum

One garage contacted indicated that they had a Nilfisk system, but now use the vacuum without the enclosure. They claim to have tests, which PEI is trying to obtain, indicating that worker exposure is the same with or without use of the enclosure/air gun.

4.2 RANKING OF TECHNIQUES

Because the tests cited in Section 4.1 represent only a rough estimate of exposures by control type, this section ranks the techniques only into broad categories rather than individually.

The first category, uncontrolled dust displacement methods, is clearly unacceptable and should be discouraged. These include the use of a compressed air gun, a dry brush or rag, or a shop vacuum not equipped with a HEPA filter. Data from only one facility indicate that the use of a damp brush or rag also fits into this category. Although no exposure data were found, the use of aerosol brake cleaner should probably also be placed in this category.

The second category, wet methods, shows considerable improvement from standard practice, but which still result in some worker exposure. These methods include use of a water hose, brake cleaner with a compressed air gun, and the Ammco brake washer. Indications are that, with good work practices, these methods could be effective in minimizing worker exposure. Testing of these practices is necessary to confirm this opinion.

The third category, vacuum/enclosure systems, is the best control available. These include the Clayton, Hako, and Nilfisk systems. These systems can clearly be recommended but may meet resistance because of cost and mechanic resistance. The use of a vacuum with a HEPA filter to vacuum the dust without using an air gun may also fit into the third category, but there are no hard data to support this position.

SECTION 5

CONCLUSIONS AND RECOMMENDATIONS

Table 5-1 summarizes the advantages and disadvantages of each of the techniques and systems discussed in this report. The following conclusions may be drawn from these data:

1. Several uncontrolled dust displacement methods in common use clearly result in higher worker exposure to asbestos. These include the uncontrolled use of a compressed air gun or a shop vacuum not equipped with a HEPA filter. Although there are work practices that could reduce the problem with these techniques (such as blowing the dust downward or venting the vacuum out a door), the methods are inherently likely to result in higher exposure. Use of a dry or wet brush or rag offers some improvement in mitigating asbestos exposures, but the results of personal monitoring are highly variable and dependent on work practices. Although no exposure data were found, the use of aerosol brake cleaner probably also fits into this category. Because these methods are so prone to misuse (e.g., contamination of clothing, accumulation of dust on the garage floor, inadequate clean-up of work areas, etc.), their use should be discouraged.

2. A group of wet methods shows clear improvement from standard practice, but still results in some exposure. These methods include the use of a water hose, brake cleaner with a compressed air gun, and the Ammco brake washer. These methods are low enough in cost to be available to even the smallest garages. Worker education is necessary, however. For example, two garages contacted had the Ammco system, but neither was using it to wash brake housings, but

TABLE 5-1. SUMMARY OF CONTROL TECHNIQUES

Technique or system	Advantages	Disadvantages	Capital cost, $	Comments
Compressed air gun	None	Higher worker exposure than any other technique tested	None	Probably the worst method
Dry brush or rag	May reduce exposure levels from air gun work area; easy to on worker's clothes	High worker exposure; asbestos remains in	None	Almost as bad or could be worse than compressed air gun
Damp brush or rag	May reduce exposure levels from air gun and dry brush or rag	High worker exposure; asbestos remains in work area; easy to get on worker's clothes; gives workers false sense of safety	None	Highly variable control based on how much water is used
Water hose	Low cost; relatively good control; can remove asbestos from work area; immediately available to all mechanics	Does not eliminate exposure; asbestos left on floor could be reentrained	None	Exposure using hose is less than the exposure for liquid squirt bottle
Brake cleaner/aerosol	Low cost; cleans grease off brake housing	Blast from aerosol can cause fibers to become airborne; quick evapore- allows for reentrainment	< 50/yr	Although there is no monitoring; data exposures are likely to be high
Brake cleaner/compressed air	Low cost appears to some lowering of exposure; cleans grease off brake	Does not eliminate exposure; if solvent is allowed to dry on floor asbestos can be reentrained	< 50/yr	Can be used with Ammco brake assembly washer
Vacuum/shop vacuum	None	Entrains virtually all asbestos into air; gives workers a false sense of safety	45 - 119	Workers should be warned that are not trapped by an ordinary shop vacuum
Ammco Brake assembly, washer model 1250	Lowers worker exposure; low cost; allows mechanics free movement	Exposures higher than with vacuum systems; possible improper disposal of asbestos	252	Can be used as a degreaser
Clayton Associates, Inc., brake cleaning equipment	Best worker protection; allows for proper disposal of asbestos	Relatively high cost; restricts worker movement; vacuum must be stronger than air blast	3,000 - 3,100	Can virtually eliminate worker exposure
Nilfisk Minuteman vacuum system	Best worker protection; allows for proper disposal of asbestos	Relative high cost; restricts worker movement; vacuum must be stronger than air blast	1,100 - 1,600	Can virtually eliminate worker exposure
Nilfisk Asbesto-Clene system	Best worker protection; allows for proper disposal of asbestos	Relative high cost; restricts worker movement; vacuum must be stronger than air blast	1,536 - 4,429	Can virtually eliminate worker exposure
Vacuum-fed filter	Lower worker exposure; appeals to mechanics; lower cost than enclosure systems; allows for proper disposal of asbestos	May allow higher exposure than with enclosure	800 - 1,100	Need to quantify worker exposure

rather only as a parts washer. The system was felt to be unnecessary because new brake shoes containing asbestos were no longer installed by these garages. Many older brakes serviced at these shops do contain asbestos, however.

3. The best control is vacuum/enclosure systems such as the Clayton, Hako, and Nalfisk systems. Resistance to the use of the enclosure and the relatively high cost of such systems may be mitigated by the use of a HEPA filter vacuum only. Preliminary indications are that this approach may be equivalent in protection.

4. Although good control systems are available, PEI's contacts indicated that their use is not widespread. During the study, we contacted control equipment vendors, major fleet brake maintenance shops, and retail brake shops in the Cincinnati and Dayton areas. This was not a scientific survey, but nevertheless we found few instances in which such equipment is being used.

PEI therefore makes the following recommendations:

1. Exposures should be characterized while mechanics use a water hose, brake cleaner with compressed air gun, and the Ammco brake assembly washer to determine specific work practices that could minimize exposure. These work practices include variations in the air pressure in the air gun, varying in the amounts of water or solvent used, and type of solvent.

2. Exposures should also be characterized during use of a HEPA-filtered vacuum to remove dust from the brake housing without use of an air gun.

PEI recommends that the following variables should be considered in any future testing done to quantify exposure:

1. The largest single variable that affected the measured fiber count in the data reviewed by PEI was the sample time. Sample times in future tests should be more consistent.

2. The quantity of dust should be estimated and the percentage of asbestos in the dust should be measured for each test to allow adjustment of results for differences in these variables. If possible, similar cars with similar mileage should be used in the tests.

3. Almost all testing in the past has been done in locations that have been contaminated with asbestos. In several tests it was mentioned that this contamination or contamination of the mechanic's clothing affected the results of the test. A clean site should be selected for future testing to minimize the problem.

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APPENDIX A

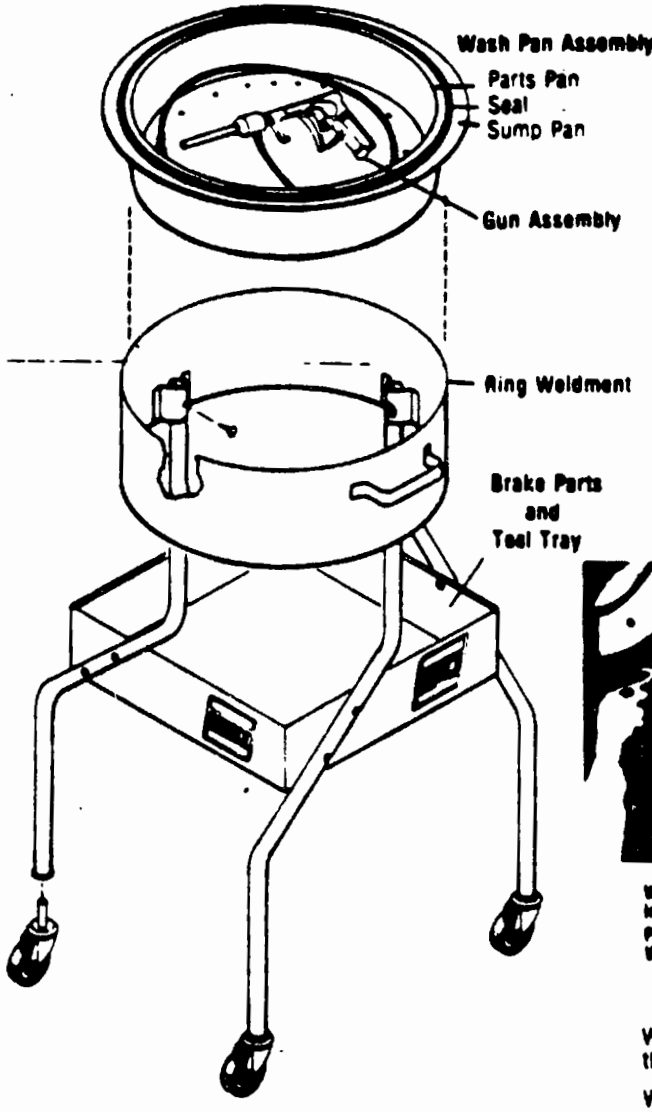
VENDOR LITERTURE

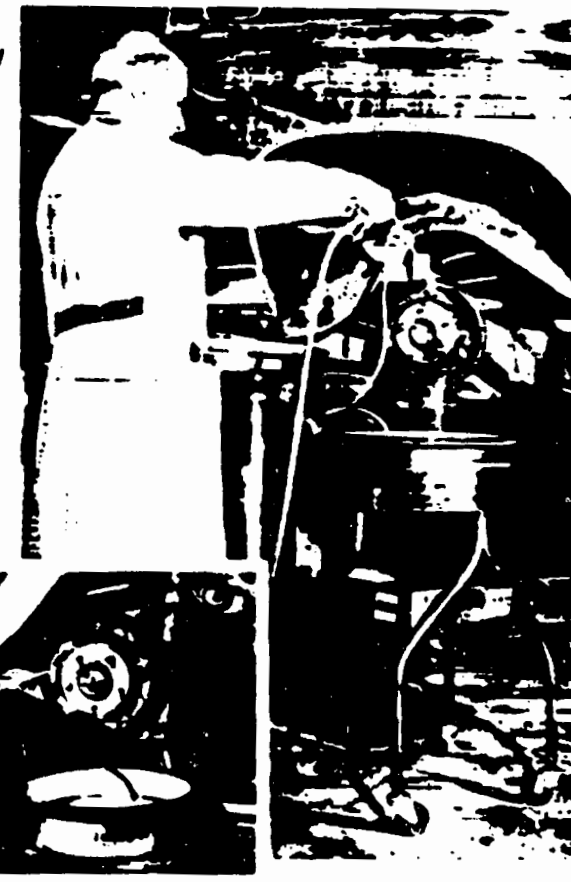
AMMCO BRAKE ASSEMBLY WASHER

MODEL 1250

AMMCO BRAKE ASSEMBLY WASHER MODEL 1250

AMMCO TOOLS, INC. / WACKER PARK / NORTH CHICAGO, ILLINOIS 60064 U.S.A. / (312) 689-1111
CABLE: AMMCO EXP / TELEX: 254795





Washing brake assemblies is a quick, easy job. The washing solution drains into the Sump for recirculation.

Parts Pan and Sump Pan (Wash Pan Assembly) can be removed from the Washer Stand for close-quarters work. (Small photo)

ASSEMBLY

1. Install the Casters in the Grip Sleeves if the four Legs.
2. Bolt the Legs to the square Tool Tray keepingthe screw holes that are at the top of the Leg facing inward.
3. Stand this Leg and Tray assembly upright and slip the Ring Weldment over the Legs. Press and tap the Ring onto the Legs until the screw holes are aligned. Faston Ring and Legs together with the four sheet metal screws.
4. Place the Wash Pan Assembly in the Ring and fill the Pan with one gallon of AMMCO No. 1256 safe Washing Solution
5. Connect an air line to the base of the Gun Handle **Maximum air pressure 150 PSI.**

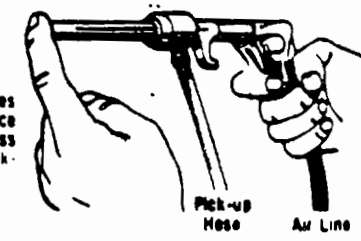
OPERATION

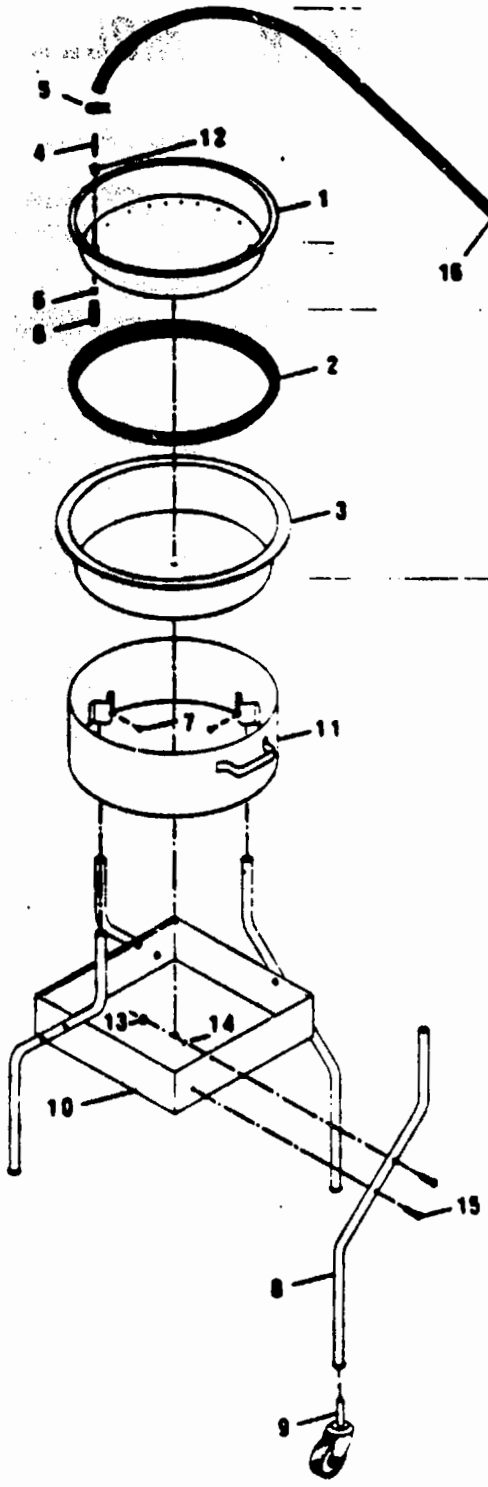
Wash the brake assembly as illustrated. Drop the parts into the Pan as the brakes are disassembled to prevent their loss.

When the Washer is not in use the fluid will drain into the Sump. To avoid blowing brake dust around the shop area start the pumping action first by aiming the Gun into the Pan and depressing the Trigger.

HOW TO UNCLOG GUN

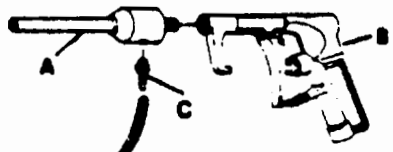
As Washing Solution becomes dirty, the Gun may clog. Place finger over Barrel and depress Trigger to back-flush the Pick-up Hose.





GUN ASSEMBLY 20630

A - 20733 Nozzle
B - 20624 Gun
C - 6122 Hose Connector



Item	Part No	Qty	Description
1	20634	1	Parts Pan
2	20631	1	Seal
3	20635	1	Sump Pan
4	20619	1	Tube
5	20644	2	Hose Clamp
6	20623	1	Hose, 2"
7	11088	4	Sheet Metal Screws
8	20629	4	Leg
9	20620	4	Caster
10	20636	1	Tool Tray
11	20633	1	Ring Weldment
12	20618	1	Snap Bushing
13	11213	8	Nut
14	5999	8	Lock Washer
15	20749	8	Round Hd Screw
16	20622	1	Hose, 36"

AMMCO NO. 1256 safe washing solution is recommended for use in the Model 1250 Brake Assembly Washer. A carton of 20 - 1 oz. packets of Concentrate makes 20 gallons of washing solution.

DIRECTIONS: Pour one gallon of water into top Parts Pan of Brake Washer (it will drain into Sump). Add contents of one packet of No. 1256 Concentrate to top Parts Pan. Dissolve Concentrate by operating Gun and saturating the Concentrate with water from the Sump.

CLAYTON ASSOCIATES, INC.

BRAKE CLEANING EQUIPMENT

ASBESTOS IN AUTOMOTIVE SHOPS!

Ceilings and pipes aren't the only places to look for ASBESTOS HEALTH HAZARDS

A Mt. Sinai Medical Center research study, "Asbestos Exposure During Brake Lining Maintenance and Repair" (December 1975), confirmed that free ***asbestos fibers are present*** in decomposed lining dust. Virtually, all these fibers are small enough to be inhaled, although they are invisible to the naked eye.

Conventional cleaning methods still practiced in most garages and school industrial arts classes expose workers and students to *lethal* concentrations of asbestos fibers.

The use of common industrial vacuums, without H.E.P.A. filters, to collect asbestos-ridden dust actually creates a greater hazard: microscopic asbestos fibers pass through the filters and are blown into the air to be inhaled.

BE ASBESTOS FREE...

...Use the only equipment designed with
SAFE FILTER CHANGE™ and 99.999% FILTRATION.

CLAYTON ASSOCIATES
BRAKE CLEANING EQUIPMENT

PROTECT ***WORKERS AND STUDENTS***

PROTECT ***THE ENVIRONMENT***

PROTECT ***AGAINST COSTLY LEGAL SUITS AND JUDGMENTS***

with
CLAYTON ASSOCIATES
BRAKE CLEANING EQUIPMENT

TOTAL CONTAINMENT prevents the release of asbestos-ridden dust into the environment while protecting the operator from contact.

- Two Attached Gloves
- Protective Storage Cover
- Most Brake Drums Removed Within Enclosure
- Blow Off Gun, Brush, Crevice Tool and Vacuum Hose Confined to the Enclosure.

SAFE FILTER CHANGE™, an exclusive feature of C.A.I. Brake Cleaning Equipment. Using competitive equipment, filter changing is the most hazardous part of the job.

- Prevents the release of contaminated dust during the changing of disposable filters
- Provides that necessary margin of safety
- U.S. and foreign patents applied for.

EASE OF USE, a prime design feature of C.A.I. Brake Cleaning Equipment, assures maximum operator acceptance and utility.

- Adjustable to vehicles on lifts or jacks
- Integrated system of vacuum, safety enclosure and tool storage tray
- Transparent enclosure sculptured for maximum visibility and light
- Accomodates all over-the-road vehicles including cars, buses and trucks

STATE OF THE ART DESIGN AND CONSTRUCTION for maximum efficiency and durability.

- High Efficiency Particulate Air (H.E.P.A.) filtration certified 99.999% efficient for particles 0.12μm (micron) or larger. (No other equipment has it!)
- Built in Manometer signals time for filter change.
- 14-gauge steel is virtually indestructible.
- Dual flow-through vacuum motors rated at 127 C.F.M. each create unequalled suction.

- SAFE FILTER CHANGE
  - — Prevents the release of contaminated dust during the changing of disposable filters
  - — Provides a margin of safety when operator fails to wear respirator or when respirator is improperly worn. (Operator should wear respirator properly during all filter changes.)
  - — U.S. and foreign patents applied for this unique safety performance feature

"BE ASBESTOS FREE — USE THE ONLY EQUIPMENT DESIGNED WITH SAFE FILTER CHANGE™ AND 99.999% FILTRATION"

SPECIFICATIONS

CLAYTON ASSOCIATES
Asbestos Cleaning Equipment

Air Flow (C.F.M.)	246
Power (Watts)*	2636
Cord & Length (ft.)	12/3, 50'
Capacity Dry (cu. ft.)	.82
Filter Efficiency	99.999% @ 0.12 micron
Filter Surface (sq. in.)	7753
Height Raised (in.)	74
Height Lowered (in.)	48
Length (in.)	24
Width (in.)	21
Weight (lbs.)	82
Caster Size (in.)	3

* C.A.I. Asbestos Cleaning Equipment is available powered by compressed air for spark-free operation.

Manufactured by:

Clayton Associates, Inc.
P.O. Box 589 • 30 Southard Avenue, Farmingdale, N.J. 07727 • (201) 938-6700

COLLECTION & DISPOSAL SYSTEMS FOR ASBESTOS AND OTHER HAZARDOUS SUBSTANCES

HAKO MINUTEMAN

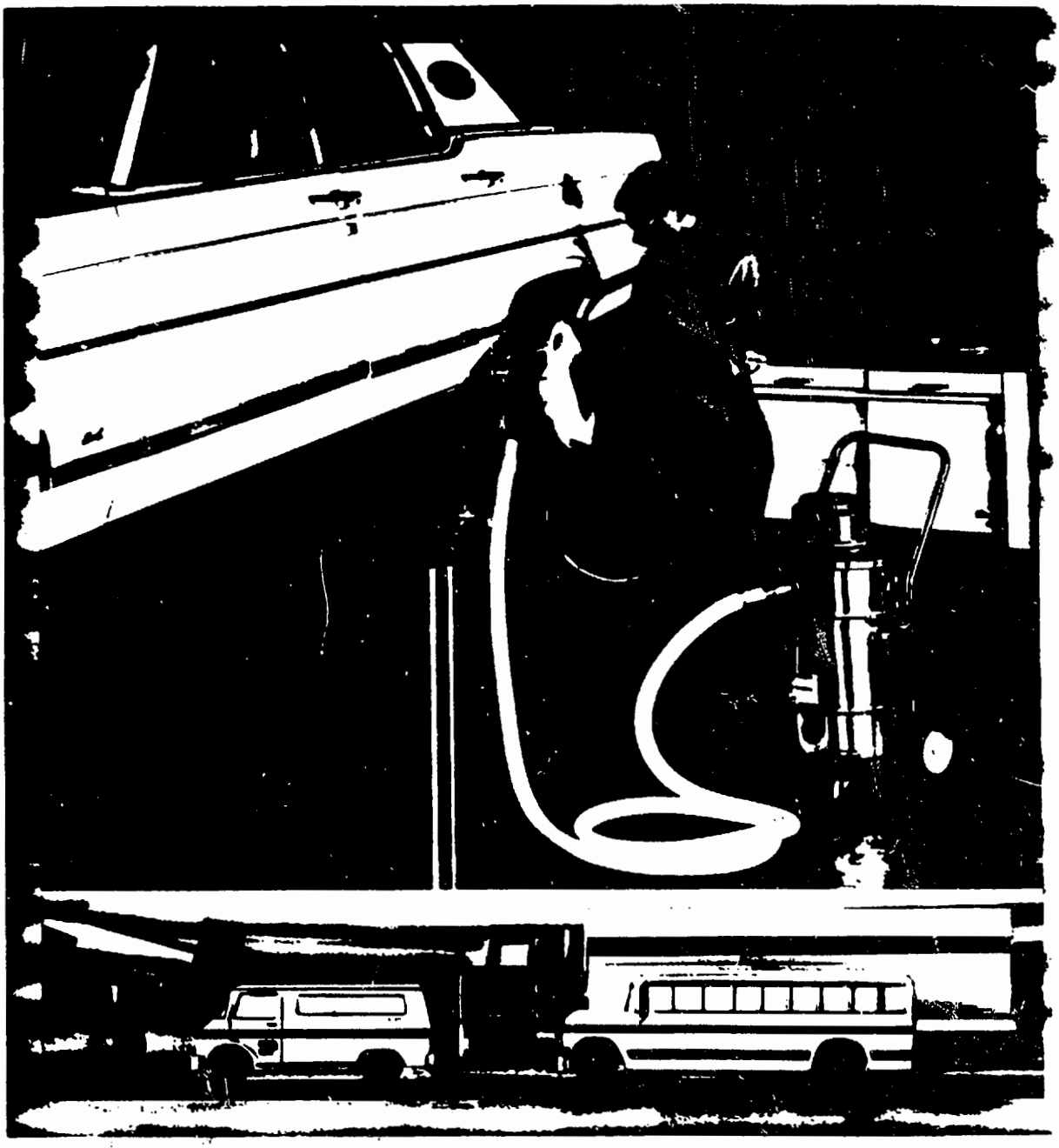
ASBESTOS BRAKE DRUM VACUUM SYSTEM

Hako Minuteman

Asbestos Brake Drum Vacuum System

Featuring Hako's exclusive Clear-View * Heavy Duty Vinyl Hood

*Patent Pend



The Safest and Most Effective Way to Control and Remove Asbestos Dust from Brake Drums

Take a look at Hako Minuteman

The Effective Way to Protect your Employees, Customers and Business from the Hazards of Asbestos.

Asbestos—a recognized public health hazard

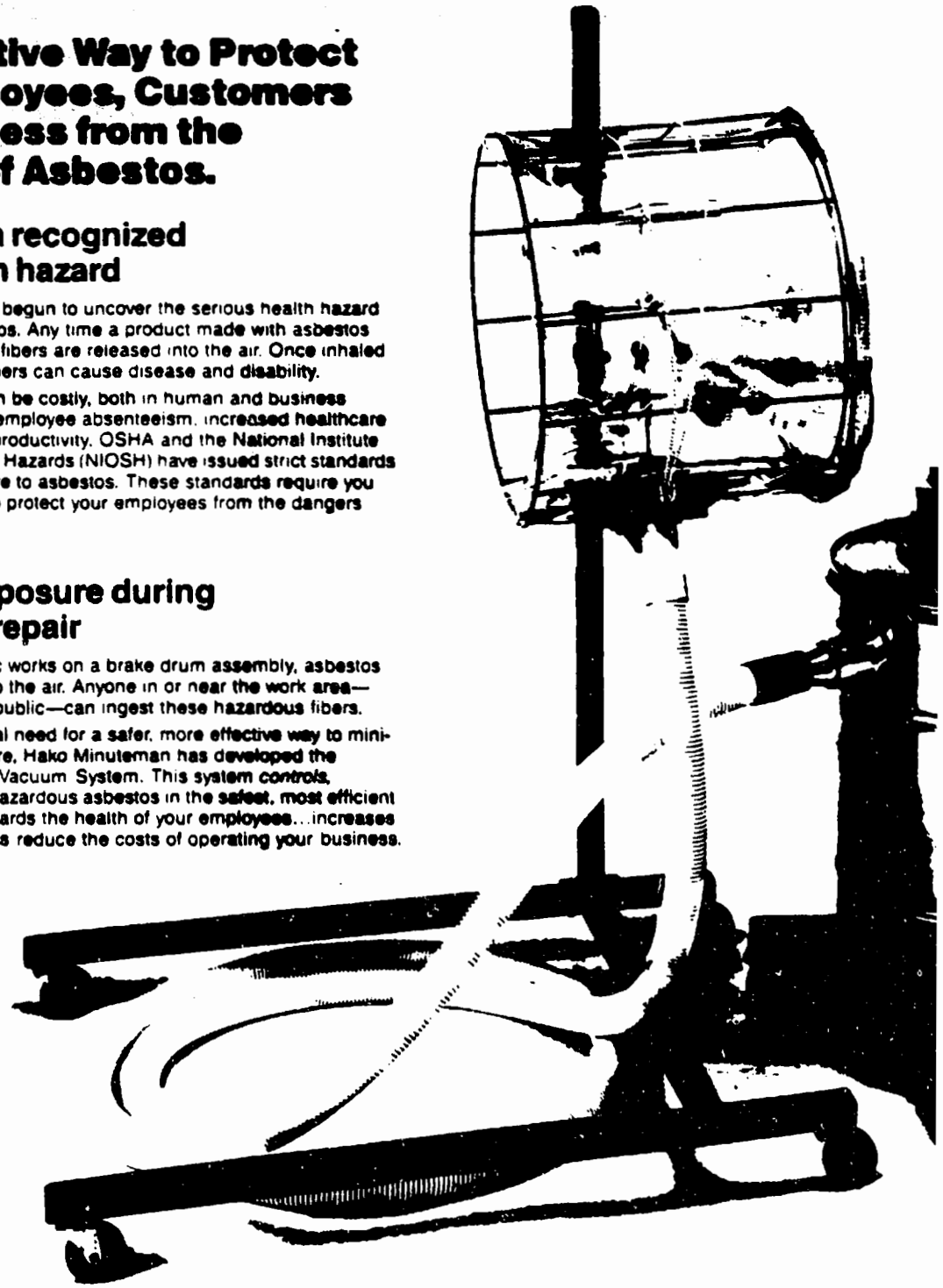
Reseachers have only begun to uncover the serious health hazard represented by asbestos. Any time a product made with asbestos is disturbed, asbestos fibers are released into the air. Once inhaled or swallowed, these fibers can cause disease and disability.

Asbestos exposure can be costly, both in human and business terms. It can result in employee absenteeism, increased healthcare costs and decreased productivity. OSHA and the National Institute of Occupational Safety Hazards (NIOSH) have issued strict standards to limit worker exposure to asbestos. These standards require you to take certain steps to protect your employees from the dangers of asbestos exposure.

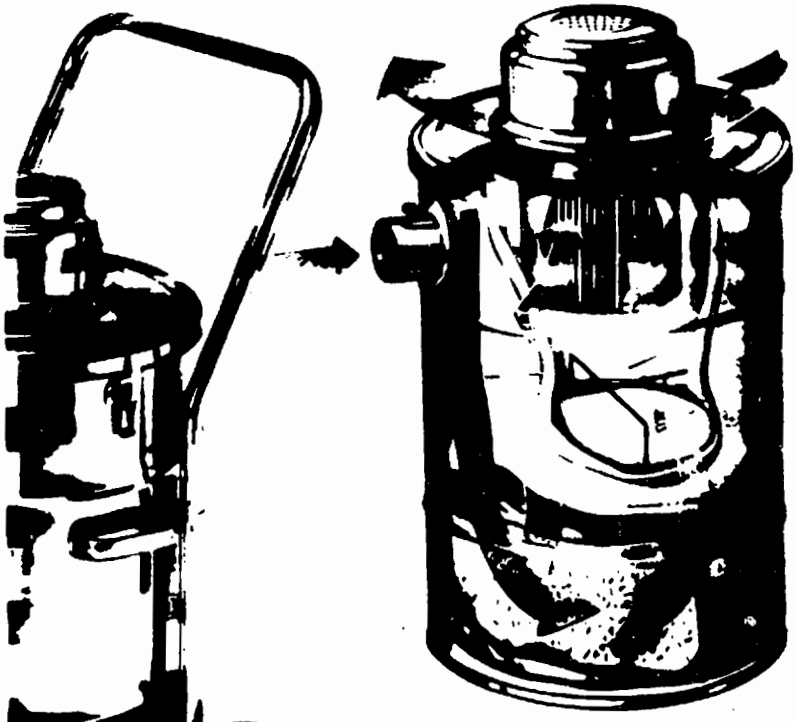
Asbestos exposure during brake drum repair

Every time a mechanic works on a brake drum assembly, asbestos fibers are released into the air. Anyone in or near the work area—including the general public—can ingest these hazardous fibers.

Recognizing the critical need for a safer, more effective way to minimize asbestos exposure, Hako Minuteman has developed the Asbestos Brake Drum Vacuum System. This system *controls, isolates* and *contains* hazardous asbestos in the safest, most efficient way possible. It safeguards the health of your employees...increases productivity...and helps reduce the costs of operating your business.



Asbestos Brake Drum Vacuum System



How Hako gives you three levels of protection:

1. Controls

Hako's exclusive Clear-View heavy duty vinyl brake drum hood covers the entire brake drum assembly to trap and contain loose asbestos. Provides *total* visibility during cleaning operations for increased safety and control. Built-in air blowing nozzle dislodges loose asbestos fibers from deep inside brake shoe lining quickly and efficiently. Protects mechanic from asbestos exposure—prevents fibers from spreading to other areas.

2. Isolates

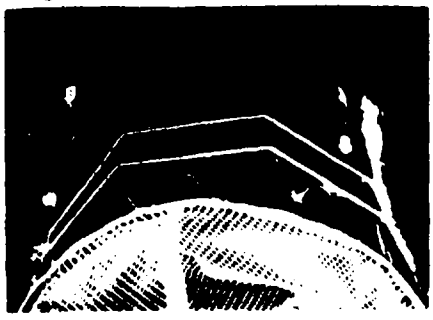
Once asbestos fibers are trapped within the hood, they are safely vacuumed through the exclusive Hako 5-stage, high efficiency filtration medium. This filtration system, designed specifically for the handling of asbestos, isolates the fibers for added safety and protection. A key component in the isolation of asbestos is a DOP (smoke) tested and registered H.E.P.A. (high efficiency particulate air) filter with a minimum efficiency of 99.97% on particles of 0.3 micrometers. Both the operator and the motor assembly are protected since all air going through the vacuum is H.E.P.A. filtered before being exhausted into the environment.

3. Contains

Hako provides an extra measure of operator protection in the handling and disposal of hazardous asbestos. Asbestos fibers are collected in a disposable filter bag which is surrounded by a heavy duty plastic tank liner. This liner is marked "Contains Asbestos Fibers," complying with Federal regulations. The operator simply closes the top of the plastic liner and lifts it—with the filter bag safely inside—out of the tank for safe and easy disposal.

A versatile, portable system that's easy to operate

Operating Procedures



1. Open aperture to full open position.
2. Install drum cleaner on brake assembly.
3. Draw bunge cord so that vinyl hood completely encases brake assembly.

4. Attach 1½" vacuum hose to inlet tube.
5. Turn on asbestos vacuum.

6. Use air blowing nozzle to dislodge dust around brake assembly.

Product Features:

Asbestos Vacuum

- Your choice of 6, 15, 30 or 55 gallon asbestos vacuum.
- Optional adaptor ring allows use of standard 30 or 55 gallon disposable containers.
- All asbestos-laden air is H E P A filtered before release into the environment.
- Hako Minuteman critical filter vacuums are easily adapted for wet recovery.

A full range of tools and attachments available.

Exclusive Clear-View Heavy Duty Vinyl Hood

- Allows total operator visibility during cleaning operation.
- Covers entire brake assembly to contain asbestos.
- Built-in air blowing nozzle firmly secured to hood to prevent accidental removal.
- Mounts to Dolly Stand for total mobility and easy access to different working heights and vehicles.
- Available in two standard sizes for cars (adjustable from 7" to 12" in diameter) trucks, buses (adjustable from 12" to 19" in diameter) even aircraft.

Dolly Stand

- Mounts to Brake Drum Hood to form a complete, portable cleaning unit.
- Constructed of rugged structural steel for long-term durability.
- Fitted with casters for total mobility.
- Allows adjustment of Hako Brake Drum Hood to working heights of up to 5 feet.

If you repair brakes, you need the Hako Asbestos Brake Drum Vacuum System

Ideal for:

Auto Dealers

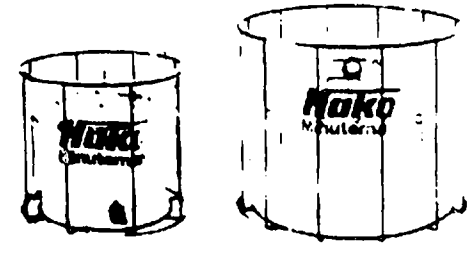
- National Chain Automotive Service Centers
- Independent Repair Shops.
- Truck Fleet Operators
- Public and School Bus Systems
- Car and Truck Rental Companies
- Municipal and Industrial Fleets
- Aircraft Repair Operations

The Hako Asbestos Brake Drum Vacuum System, featuring the exclusive Clear-View vinyl hood, was designed for the safe control of asbestos during brake drum repair. For more information about this effective, cost-efficient way to protect your employees, customers and business call Hako Minuteman today!

Specifications

	Asbestos -6	Asbestos -15	Asbestos -30	Asbestos -55
Static Lift (inches Water)	88	88	88	88
Air Flow (C.F.M.)	95	95	95	95
Power (Watts)	930	930	930	930
Cord & Length	16-3/50	16-3/50	16-3/50	16-3/50
Wet Capacity (gallons)	N.A.	optional	optional	optional
Dry Capacity (cu. ft.)	21	82	4.36	7.15
Filter Area Total Square Inches	2,226	4,120	4,120	4,120
Overall Height	25	36	48	54
Width	14	21	25	25
Volts—Standard / Optional	115 / 220	115 / 220	115 / 220	115 / 220
Wheels	optional	yes	yes	yes
Wheel Size—Front / Rear	3 / 5	3 / 8	5 / 5	5 / 5
Wet Dry	N.A.	optional	optional	optional
Dry Only	yes	yes	yes	yes
Weight Pounds	24.5	51	121	135

Specifications subject to change without notice



Hako offers a full line of Critical Filter Vacs
• Industrial/Commercial/Institutional Vacs Sweepers Scrubbers Floor-Carpet Machines.

Hako Minuteman

111 South Route 53, Addison Illinois 60101 • Phone (312) 627-6900 • Telex 910-991-3992

987825 12 84 5 M 2593

NILFISK ASBESTO-CLENE

SYSTEM

Nilfisk Asbesto-Clene® Systems

Fast brake jobs and no asbestos mess.
The only way to do thorough brake cleaning and still meet federal asbestos exposure limits.

Nilfisk Asbesto-Clene® Systems

The Nilfisk Asbesto-Clene systems are engineered to meet and exceed OSHA and EPA standards for minimizing exposure to asbestos dust without sacrificing speed and ease of brake lining work. A cylinder isolates the brake drum. A Nilfisk vacuum connected to the cylinder prevents the escape of airborne asbestos dust generated during clean-up with the cylinder's compressed air gun. Filters inside the vacuum assure that none of the dust is exhausted to the workplace. Debris is collected in disposable bags.

Heavy Duty Vacuums. All Nilfisk vacuum dust collectors used in these systems are equipped with cam microfilters and HEPA filters so they return absolutely clean air to the work area. Tested and approved by the Asbestosis Research Council, these same vacuums are widely used in brake and clutch manufacturing plants to control asbestos dust.

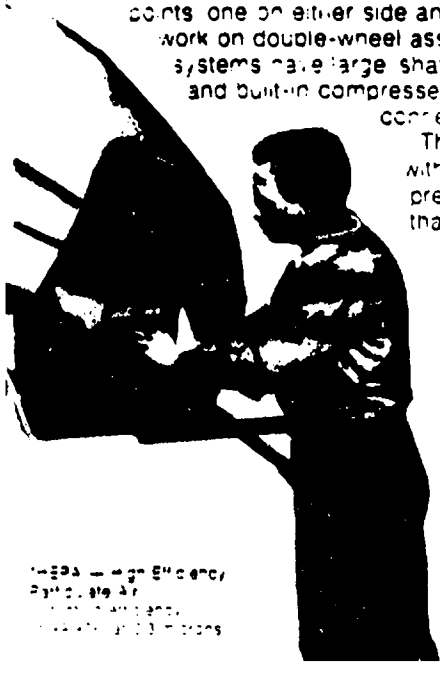
Easy-to-Use Encapsulators. Encapsulator cylinder No. 017400 is used in Systems 400 and 600 and fits passenger cars and light commercial vehicles with brake drums in the 7 to 12 diameter range. Asbesto-Clene System 400 is used in low racks. The System 600 stand can be adjusted for use with hydraulic lifts. Nilfisk Vacuum Model GS 81 is normally used with Systems 400 and 600.

Cylinder No. 017500 is used in Asbesto-Clene System 600 for its large commercial vehicles with brake drums in the 12 to 19 diameter range. Its stand is for use with low racks. Nilfisk Vacuum Model GS 83 is normally supplied with System 600.

System 400 has a cotton sleeve which allows a mechanic to reach safely inside to do brake cleaning quickly and comfortably. System 600 has three access points, one on either side and one in front, making work on double-wheel assemblies easy. Both systems have large shatterproof viewing windows and built-in compressed air guns with quick-connect couplings.

The combination of vacuum with safety *enclosed* compressed air gun is faster than wet wiping, and eliminates the asbestos dust exposure you get when using an *exposed* air gun.

When not in use for brake lining work, Nilfisk vacuums can be disconnected from the encapsulator and used separately for clutch-facing work, arc grinders or routine cleaning around the garage.



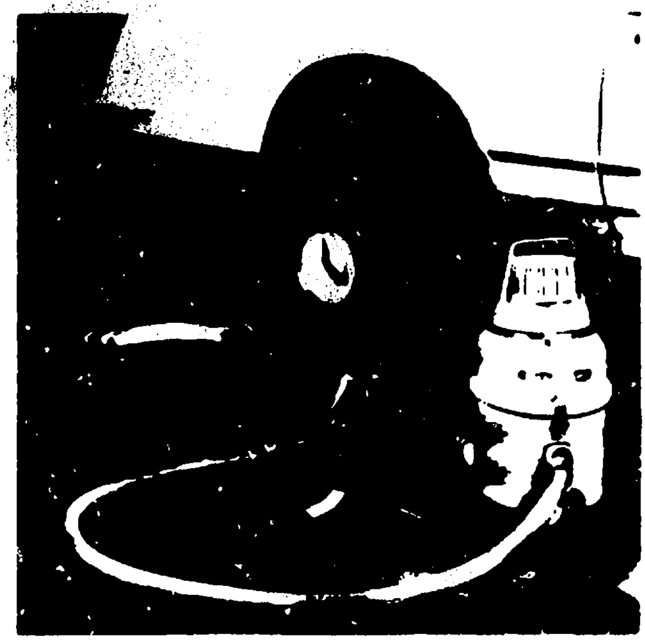
HEPA — High Efficiency Particulate Air [illegible]

Asbesto-Clene System 600. Recommended with vacuum Model GS 81 wherever volume passenger car, light truck brake lining work is done. Comes with stand for use with high lifts.

1. Encapsulator Cylinder (017400 shown) with single access viewing window *enclosed* air gun.

2. Vacuum (Model GS 81 shown) with HEPA filter, hose, disposable bags and steel wand.

3. High Lift Stand (017501) for vehicles up on hydraulic lifts (as shown).



Asbesto-Clene System 400. Recommended with vacuum Model GS 81 where low volume passenger car, light truck brake lining work is done. Comes with stand for use with [illegible] jacks.

Asbesto-Clene System 600. Recommended with vacuum Model GS 83 wherever volume brake lining work is done [illegible]

[illegible] jacks

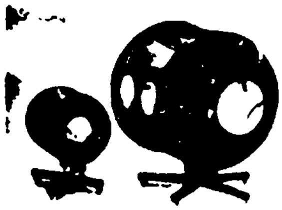
Easy disposal of asbestos dust

1. External shaking handle releases all debris from filter. Dust collects in enclosed container.

2. Lower the container which holds either poly liners or disposable bags.

3. [illegible] disposal.

Optional Manometer on Models GS 82 and GS 83 alerts mechanic when filter needs to be shaken. Cleaning the filter regularly maintains high suction and filtration efficiency and extends filter service life.



Customized encapsulators [illegible]

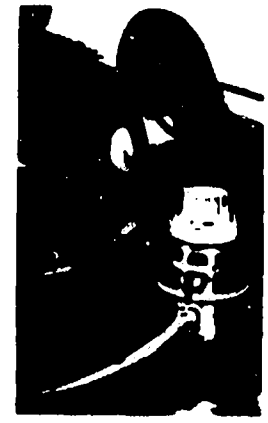
ASBESTO-CLENE® COMPONENTS	Heavy Duty Systems			Light Duty Systems		
	System 400	System 500	System 600	System 400(80I)	System 500(80I)	System 600(82)
Model GS 80 Vacuum, 7½ gal. capacity				■	■	
Model GS 81 Vacuum, 7½ gal. capacity	■	■				
Model GS 82 Vacuum, 12 gal. capacity						■
Model GS 83 Vacuum, 18 gal. capacity			■			
No. 400 Encapsulator	■	■		■	■	
No. 600 Encapsulator			■			■
Low Stand	■		■	■		■
High Lift Stand		■			■	
Microfilters	■	■	■	■	■	■
HEPA filters	■	■	■	■	■	■
10' Hose, 1½" ID	■	■		■	■	
10' Hose, 2" ID			■			■
Disposable Filter Bags	■	■		■	■	■
Sealable Polyliners			■			
Manometer (Optional)			■			■

One vacuum cleaner attachment is available for use with each system.

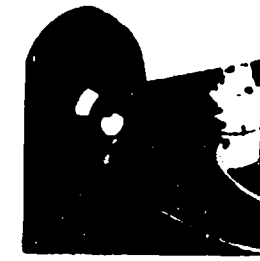
National Representatives.

Nilfisk has a nationwide network of representatives all thoroughly familiar with government codes and regulations dealing with the safe cleanup of asbestos dust. For more information or to contact your nearest Nilfisk representative for specific recommendations call or write Nilfisk of America Inc., 224 Great Valley Parkway, Malvern, PA 19355 (215) 647-6420

Other Nilfisk Asbesto-Clene Systems for Light Duty



Asbesto-Clene System 400(80I). Recommended with vacuum Model GS 80 for use in garages where only occasional brake lining work is done. Comes with stand for use with low jacks.



Asbesto-Clene System 600(82). Recommended for garages where only occasional brake lining work is done on large commercial vehicles with brake drums in the 12 to 19" diameter range in double wheel assemblies. Comes with stand for use with low jacks.

Asbesto-Clene System 500(80I). Same as system 400 (80) except encapsulator stand is for vehicles up on hydraulic lifts.

Nilfisk

Dust Collection Specialists Since 1910

APPENDIX B

SUMMARY OF ANALYTICAL METHODS FOR ASBESTOS

TABLE B-1. SUMMARY OF ANALYTICAL METHODS FOR ASBESTOS

Method	Feature examined	Comment
Light microscope		
1. With phase contrast at 400X	Morphology	Limit of resolution about 0.5 um.
2. Dispersion staining	Refractive index and and morphology	Skilled operators can distinguish asbestos fibers. Limit of resolution about 0.5 um.
X-ray diffraction	Crystal structure	No information on fiber size or size distribution.
Infrared spectroscopy	Characteristic absorption	Ambiguity is possible. No information on fiber size or size distribution.
Atomic absorption	Elemental composition	No size or size distribution information. High sensitivity for trace elements.
Neutron activation	Elemental composition	No information on size or size distribution. Specialized nuclear equipment needed.
Emission spectroscopy	Elemental composition	No size or size distribution information. Both gross and trace constituents determined.
Thermal analysis TGA and DTA	Weight loss on heating due to dehydroxylation	No information on size or size distribution. specificity to asbestos not yet resolved.
Scanning electron microscope with microprobe	Surface topology of the fiber and elemental analysis	Most SEM's have a theoretical resolution limit of about 10.0 to 20.0 nm. Background can give interference.
Transmission electron microscope with microprobe	Shape outline, electron diffraction, and elemental analysis	Resolution limit down to 0.40 nm. Transfer to grid can lead to statistical errors in counting.

Source: Reference 15.