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Characterization of Vehicular Brake Service Personnel Exposure to Airborne Asbestos and Particulate

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Evaluation of fibers and total particulate generated during the servicing of drum brakes on motor vehicles as well as during the resurfacing (arcing) of brake shoes was conducted. Conditions for the studies were based on review of contemporary (~ 1950–1980) working practices in the industry. This work was conducted in two parts. Phase 1 estimated the release of asbestos fibers and total particulate during brake inspection and replacement of light-duty vehicle rear drum brakes at an auto/truck repair facility. Two distinct work practices were evaluated: One rear wheel from each vehicle was serviced using compressed air to remove dust while the second rear wheel was serviced without compressed air. Area and personal monitoring of fiber levels demonstrated counts (without compressed air) that ranged from 0.05 to 0.2 f/cc. Fiber counts when using compressed air averaged from 0.05 to 0.9 f/cc. Results from real-time aerosol monitoring indicated elevated dust levels for about 15 minutes after blow out. With shop doors open, dust levels increased to 5.0 mg/m^3 at blow out and returned to 0.08 mg/m^3 within two minutes. When the shop doors were closed, the dust levels reached 13.5 mg/m^3 at blow out and decreased to 1.68 mg/m^3 within one minute and to background within 14 minutes. The Phase 2 series evaluated the release of fibers and other particulate from arc grinding. For operations conducted under conditions simulating a workplace, a mean of 0.19 f/cc ± 0.16 was determined. Dust levels averaged 0.25 mg/m^3 ± 0.05. Brake service monitoring in these tests demonstrates that asbestos fiber concentrations, considered on a time weighted average basis, should not exceed currently acceptable workplace standards whether or not the worker uses compressed air, nor during the arc grinding process when arcing is conducted in accord with the design of the equipment.

Keywords Arcing, Asbestos, Automotive Brakes, Brake Repair, Brake Shoes, Friction Materials, Grinding, Particulate, Respirable

Work activities associated with servicing and replacement of vehicular brake friction products have been of interest to health scientists for the past 2 or 3 decades based on a projected potential for asbestos fiber release. Publicly available studies, both published and unpublished,(1–10) of the past 30 or so years demonstrate a concern that workers who conducted brake maintenance and repair during the interval when asbestos fibers were prevalent in these products may have been exposed to concentrations of asbestos fibers in excess of acceptable standards. It has been variably estimated that approximately 150,000(10) to 900,000(8,11) individuals have worked in this industry and have a potential for exposure to brake maintenance and repair work. There is a continuing consideration by some of these workers that they may be candidates for disease even though the epidemiological evidence supports that disease is unlikely.(11–14) More often than not, the presence of visible dust in the air during brake servicing tasks has served as an alert to individuals that there may have been an asbestos-related problem.

In response to the continuing concerns, a series of investigations were conducted to evaluate both the presence of asbestos fibers available to the brake service worker as well as the total particulate generated during operation of the various procedures. The studies outlined in this report evaluate the levels of asbestos fiber and particulate during the servicing of drum brakes on light-duty motor vehicles as well as the resurfacing (arcing) of brake shoes to accommodate newly ground (turned) drums. This work was conducted in two parts, Phases 1 & 2. The purpose of the Phase 1 experiment was to estimate the release of asbestos fibers and total particulate during brake inspection and replacement of light-duty vehicle rear drum brakes. Until recently, the brake mechanisms on many light-duty vehicles were

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drum-brake systems. This "closed" system permitted accumulation of abraded brake pad dust within the brake drum. During servicing of the brakes on such vehicles, the drum was removed so that the brake shoes could be inspected. Before inspection it was common to remove the accumulated dust using compressed air. If it was necessary to change the brakes, the old shoes were removed and discarded. A new set of brakes was then installed, adjustments were made, and the brake drum was replaced.

A second series of experiments (Phase 2) evaluated the potential for release of fibers and other particulate resulting from the arc grinding process. An arcing machine typical for the interval of greatest use was utilized to estimate the levels of airborne fibers and particulate in the operator breathing zone and immediate work area during the arcing of asbestos-containing brakes.

Finally, an experiment was conducted to estimate the quantity of asbestos-containing dust that remained on the operator's clothing after completing the arcing test sequences.

The conditions developed for the studies reported herein were based on a review of the contemporary working circumstances in the industry during the time when drum brakes and arcing were prevalent in the interval centering on the 1960s.

BACKGROUND

During the operating life of an automotive drum-brake system, the brake shoe wears away at a rate determined by the application of the brakes. In turn, the portion of the metal drum in contact with the brake shoe also wears to some extent. Therefore when servicing the system, in addition to replacing the shoes, it was sometimes necessary to remove the imperfections (i.e. ridges) that develop as a result of such drum wear. The procedure of smoothing the metal surface (referred to as "turning") resulted in a slightly increased diameter for the drum. Brake shoes for this altered drum would then be shaped (or arced) to match the arc of the enlarged diameter of the drum.

The time required for turning one drum and taking measurements was approximately 15 minutes.[15] Arc grinding a pair of brake shoes required approximately one minute. On this basis, the most probable interval for arcing 4 pairs of brake shoes for one automobile would not exceed about 4–5 min/hr. Discussions with several operators of brake servicing/repair facilities in an urban area of a large U.S. city suggest that a fairly busy shop would turn a maximum of 16 drums per day, equal to 4 wheels on each of 4 vehicles or 2 wheels on 8 vehicles.

METHODS

Phase 1

To design an appropriate monitoring protocol for a "closed" drum brake system, typical brake repair and replacement processes were observed through several cycles of operation. All details of an operation with opportunity for significant generation of dust were noted. Following this process, a monitoring program was designed to evaluate dust generated during the repair and replacement of brakes from the rear wheel of vehicles in the facility.

Phase 2

For purposes of the experiments described in Phase 2, it was assumed that a worker would conduct twice as many brake jobs in a day as would occur in a typical shop. If a worker did nothing but turn drums and arc grind the brake shoes, he could complete work on 8 vehicles within an 8-hour workday.[15]

An experienced, factory-trained person operated the arcing machine for all tests in this series. This person had been the owner-operator of an after-market automotive parts supply facility located in a suburb of a major U.S. city during the interval when arc grinding was prevalent. His facility incorporated a full-service drum turning/brake-shoe arcing shop on the premises.[15]

FACILITY AND EQUIPMENT

Phase 1

The site for this study was a public service organization auto/truck repair facility. The repair facility was situated in one end of a large warehouse structure. The vehicle repair section was an area approximately 16 m × 35 m with 7 m ceilings. Five 4-m-wide doors permitted vehicle access to the service bays of the garage. Air circulation was provided by way of the space heaters suspended from the ceiling or by opening the vehicle access doors. The facility maintained a fleet of approximately 100 vehicles, including passenger cars, trucks, and vans.

Phase 2

The first test sequence of Phase 2 (identified as Run 1) was conducted in a suburban garage setting, approximately 7.2 m wide × 7.2 m long × 2.4 m high. An arc grinding machine[16] was positioned on a 60 cm × 90 cm table approximately 75 cm from the floor. The machine was situated so that the operator would be working approximately 2 m from one sidewall of the room. Environmental conditions included no detectable net air flow and a temperature of 24°C–25°C during the study. All tests and procedures for the remainder of the Phase 2 experiments were conducted within a shop/laboratory room approximately 8.5 m wide × 13 m long × 5 m high provided with positive flow ventilation. The experiments were confined to a dynamic flow exposure chamber similar in design to that of Hinners et al.[17] The chamber was a 2.4 m × 2.4 m × 2.4 m cube, providing a volume of approximately 14 m^3. The walls of the chamber were 10-mil polyethylene, held in place by an external wooden frame and sealed at all joints with a silicone-based caulking. Air was exhausted from the exposure chamber via a floor-to-ceiling slot manifold located in a corner of the chamber opposite the chamber entry. The manifold was, in turn, connected to a pleated, extended-surface prefilter and a HEPA filter and then to an enclosed negative pressure blower system.[18]

Air flow through this system was maintained at a nominal 6400 L/min or 0.11 m^3/sec.

Air from the laboratory was supplied to the chamber through ports located in both the outer and inner doors of the air-lock entry system. Air pressure within the chamber was maintained at a nominal −2 mm H_2O relative to the laboratory. The pattern of air movement within the chamber was evaluated using a portable thermoanemometer.[19] Air flow within the chamber was determined to be equal to or less than 1 m/sec at a height of 1.5 m above the floor at all points within the defined working area of the chamber (i.e. the 2 m × 2 m space located in the center of the chamber room). It was not possible to discern a consistent pattern of air flow direction from the air flow readings. Temperature in the chamber was maintained at 26°C ± 2°C throughout the study.

An arc grinding machine[16] equipped with a factory-provided dust collection bag system was positioned on a 60 cm × 90 cm table approximately 75 cm from the floor. The machine was situated so that the operator would be working in approximately the center of the chamber.

For asbestos content verification, a bulk sample was collected from each of the 6 pairs of shoes used in this study. Samples were submitted to a certified independent laboratory.[20] The laboratory utilized a standard Polarized Light Microscopy (PLM) method for analysis of these samples,[21] indicating that chrysotile was the only asbestiform material present. Concentrations ranged from 50–65% chrysotile.

STUDY DESIGN

Phase 1

Three vehicles were monitored during the automotive brake inspection and replacement study, including: (a) a 1976 Chevrolet van, (b) a 1977 Chevrolet 1/2-ton pickup truck, and (c) a 1981 Ford station wagon. During two of the replacement procedures, the doors to the facility were open with a 1–2 m/sec breeze blowing through the area. During the third replacement procedure, the doors to the shop were closed. The gas heaters for the building were in operation, providing limited air circulation in the work area.

Two distinct work practices were evaluated during this part of the monitoring program. One wheel from each vehicle had the brakes serviced with compressed air that was used to remove loose, accumulated dust before inspection. The brake from the other rear wheel of each vehicle was inspected and serviced without the use of compressed air.

Phase 2

Four sequences of tests were conducted in this investigation. During the first experiment (Run 1), the operator arced the equivalent of one set of 8 shoes eight times to simulate the probable maximum use of an arcing machine during a workday. The actual arcing process required about 4–5 minutes for each set of 8 shoes. The arcing machine was turned on immediately before grinding each set, then turned off again, as would be done in a workshop situation. This process permitted eight sequences of 8 shoes to be completed during a 40-minute interval.

The second sequence (Run 2) was set up to reproduce the first sequence (Run 1) but was conducted within the chamber containment facility. The third sequence (Run 3) was set up to simulate one-half of a day's work of an arc-grinding operator primarily doing brake jobs. The operator, using 12 available brake shoes, arced each of these shoes twice to simulate brake servicing, equivalent to 3 vehicles during a 3-hour period. He worked on one set of 8 shoes at the beginning of each hour. This closely simulates the frequency and pattern of arc grinding in a brake service shop.[15] In addition, at the end of each arc-grinding session, the operator moved out of the exposure chamber, through the air lock and into other parts of the testing laboratory, as he would in a traditional brake servicing facility.

The fourth sequence (Run 4) was designed to duplicate the third sequence described above.

OPERATOR CLOTHING STUDY

In addition to the four sequences of testing presented above, the operator's one-piece suit was carefully removed and then evaluated for the presence of fibers potentially generated during his arcing work.

For this part of the investigation, a nonrigid freeform dynamic flow chamber with a volume of approximately 150 liters was constructed from 2-mil polyethylene to allow agitation of the clothing while extracting an air sample from the chamber. Filtered air from an oil-free pump was introduced into one end of the chamber containing the clothing at a rate of 2.5 L/min. After the chamber was inflated to approximately 100 L, a pump drawing 2.5 L/min of air was started at the opposite end of the chamber. Thus the chamber was maintained at a constant volume of about 100 L throughout the study. Air from the exhaust was drawn through the sampling apparatus using an air sampling pump.[22]

The experiment was operated for a period of 30 minutes during which the clothing within the chamber was agitated for each alternating 5-minute interval, then allowed to sit at rest for the next 5 minutes. This schedule of agitation and rest continued for the duration of the experiment.

ENVIRONMENTAL MONITORING

Phase 1

Monitoring for Phase 1 consisted of collecting airborne particulate at five sampling stations located at breathing zone height (1.3 m above the floor), spaced in a semi-circular pattern on a radius of 1.2 m from the center of the wheel being repaired, and a personal sampling pump placed on the worker to directly monitor his breathing zone. See Figure 1 for details of sampling locations. All monitoring was conducted at a nominal rate of

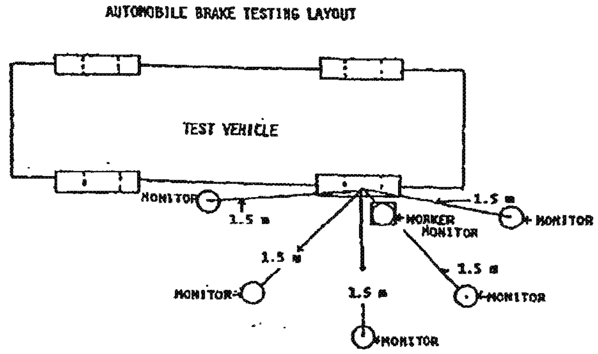

FIGURE 1
Phase 1 study showing sampling locations.

1.5 to 2.0 L/min. The sampling period at all locations was for approximately 15 minutes starting with removal of the first wheel nut through inspection, removal, and installation of new brake shoes and replacement of the brake drum.

A total of 36 samples were collected during this series. Five stationary samples and one personal sample were collected for each rear wheel of every vehicle. A real-time aerosol monitor[23] was used to evaluate the particulate levels in the area around the automobile brake replacement operation. The intake for this instrument was located approximately 75 cm from the brake being serviced at a height of approximately 1.5 m. Background levels were collected at the beginning of the work shift. Monitoring was conducted during the brake replacement procedure and continued until the monitor indicated a return to background level. The sensitivity of the instrument was set and calibrated at 0–20 mg/m^3 for particulate with a mass medium diameter less than 10 microns.

For those circumstances where accumulated dust was not removed using compressed air, bulk samples were collected by brushing the material with a camel hair brush into a 25 ml screw top vial for subsequent evaluation of content.

Phase 2

During Run 1, sampling pumps, set at a nominal flow rate of 2.0 L/min, were used to estimate the airborne concentration of chrysotile fibers in the breathing zone of the operator (located at the 12 o'clock position). Additional personal sampling pumps were set up on stands to provide general area monitoring at the breathing zone level (located at the 3 o'clock and 9 o'clock positions approximately 1.25 m to either side of the machine). These sampling pumps operated for the 40-minute duration of the experiment. Two additional area pumps, set to draw 15 L/min through the filters, were placed approximately 35 cm from the center of the dust collection system to estimate any breakthrough of fibers from the collection bag. One of these area pumps was on for the duration of the experiment. The second of these area pumps was utilized for sampling only during each arcing period (3–5 minutes for each interval).

During Runs 2, 3, and 4, the environment of the exposure chamber was evaluated for several analytes, including total fibers, respirable fibers, total dust, and respirable dust. To understand the placement of sampling apparatus within the chamber, consider that the operator stood at the 12 o'clock position facing the wall. Personal sampling pumps,[22] set at a nominal flow rate of 2.5 L/min, combined with cyclone technology[24] for respirable fraction capture (using a 4 micron cut point), were used to estimate the airborne concentration of respirable fibers and respirable particulate in the breathing zone of the operator (at the 12 o'clock position). Additional personal sampling pumps were set up on stands to provide general area monitoring at the breathing zone level (located at the 2 o'clock and 10 o'clock positions approximately 46 cm from the operator). Total airborne fiber concentrations and total particulate samples were collected in these same locations using personal sampling pumps set at a flow rate of 2.0 L/min. Fiber samples were also collected at the 6 o'clock location (immediately behind the arcing machine near the side of the chamber), both at 35 cm from the floor (this position was about 40 cm from the exhaust dust collection bag) and at breathing zone height (approximately 1.5 m from the floor). Samples were collected for the duration of each run.

All sample pumps were calibrated using a bubble meter prior to, and again after completion of, the experiments to ensure flow rates were consistent throughout the tests. Actual flow rates were provided to the analytical laboratory for sample analysis.

For the Operator Clothing Study, air was drawn at the rate of 2.5 L/min for airborne fiber determination. The sample was collected for the duration of the experiment.

ANALYSIS

Phase 1

Samples collected during Phase 1 were analyzed using Phase Contrast Microscopy (PCM) (NIOSH 239) by a qualified microscopist. Two filters from the procedure not using compressed air and 3 filters from the procedure using compressed air were analyzed using Scanning Electron Microscopy/Transmission Electron Microscopy (SEM/TEM) and Energy Dispersive X-ray analysis (EDX). All electron microscopy was submitted to an accredited and licensed testing laboratory for analysis.[25]

Accumulated dust that was collected in bulk from the drum where air was not used was analyzed using the SEM/TEM process.

Phase 2

Samples collected during the Phase 2 tests were submitted to an accredited and licensed testing laboratory for analysis.[20] The analytical laboratory utilized NIOSH Method #7400 (PCM) to evaluate all area and personal total and respirable airborne fiber samples. NIOSH Methods #0500 and #0600 were used to determine total and respirable dust concentrations. Bulk samples from the brake pads were analyzed by PLM.

RESULTS

Phase 1

In the three brake replacement operations where compressed air was not used, considerable particulate matter accumulated on the sample filters; however, there was no excessive airborne dust identifiable to the observers of the process. Fiber counts of these 16 filters (NIOSH 239) ranged from 0.05 to 0.2 f/cc of air.

The two filters analyzed using SEM/TEM methodology demonstrated either particulate not characteristic of the federally defined fiber or a few matrix-bound fibers as exhibited in Figure 2.

For the brake repair and replacement process in which compressed air was utilized to remove accumulated dust, a total of 18 samples were analyzed. Fifteen of the filters were analyzed using NIOSH 239 procedures. Fiber counts for these 15 samples averaged from 0.05 to 0.9 f/cc of air.

Three filters from this series were analyzed using the SEM/TEM procedures. The majority of structures present on the filters were less than 3 micrometers in length. Most of these structures had material adhered to them. A rare longer fiber found in these samples is presented in Figure 3, demonstrating an example of matrix material adhering to the fiber.

Accumulated dust that was collected in bulk from the drum where air was not used to clean the area was analyzed using the SEM/TEM process. An overwhelming majority of the sample was nonfibrous material, as depicted in Figure 4. Results from real-time aerosol monitoring indicated elevated dust levels (above background) following the blow out process. When air was used, with automotive shop doors open, dust levels increased to 5.0 mg/m^3 at blow out and returned to 0.08 mg/m^3 within two minutes (0.06 mg/m^3 = background). When the shop doors were closed, the dust levels reached 13.5 mg/m^3 at blow out and decreased to 1.68 mg/m^3 in less than one minute and reached background levels (0.07 mg/m^3) within 14 minutes. When air was not used, there was a small but detectable increase (to 0.09 mg/m^3) in shop particulate for a minute or so following removal of the drum, after which dust levels returned to background.

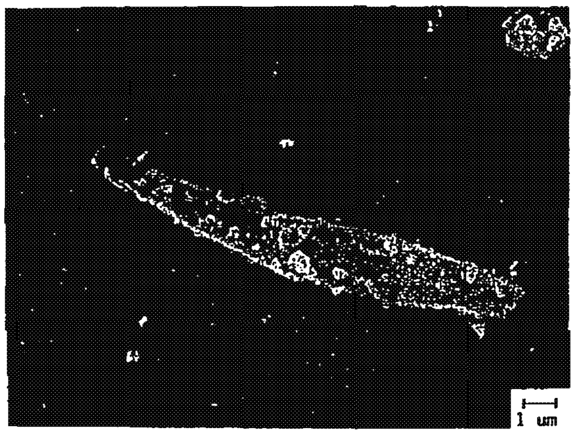

FIGURE 3
Scanning Electron Microphotograph depicting rare long fiber with adhered matrix.

Phase 2

Analyses of the air samples, both personal and area, were conducted using PCM. The personal sample level of the operator was 0.40 f/cc. The Time Weighted Average (TWA) for this sample is 0.03 f/cc. The TWA for all samples was calculated using OSHA's time weighted average calculation.[26–27] The stationary breathing zone sample levels were 0.14 and 0.45 f/cc (TWAs = 0.01 and 0.04 f/cc, respectively). The area samples

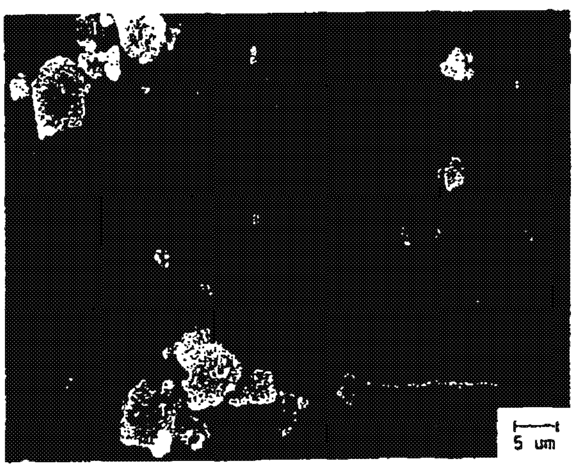

FIGURE 2
Scanning Electron Microphotograph depicting brake dust and a chrysotile fiber with attached matrix.

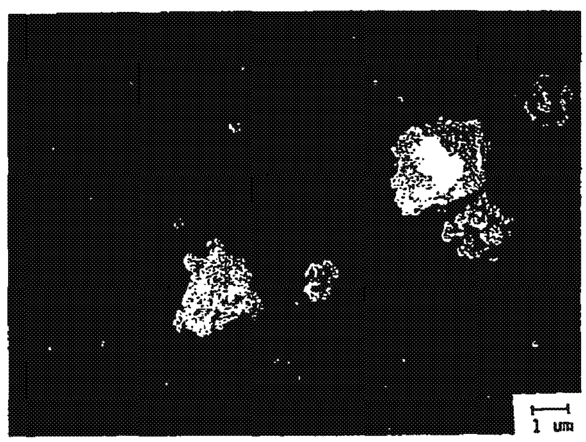

FIGURE 4
Scanning Electron Microphotograph of residue from brake drum demonstrating nonfiber particulate.

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collected approximately 35 cm from the collection bag had levels that ranged from <0.08–1.47 f/cc. The TWA for the highest area sample level is 0.02 f/cc. In addition, the operator's sample was analyzed by TEM and yielded a result of 0.86 structures/cc (TWA = 0.07 structures/cc). A few bundles and matrices were longer than 5 microns.

Review of the data from Runs 2–4 supports that there was little difference between the respirable and total fiber concentrations in each of these runs. Therefore, all fiber data points from each run were combined and utilized to determine a mean and Standard Deviation (SD), as well as a TWA. For purposes of establishing a mean and SD, data reported as "less than" numbers were assumed to be one-half the actual numeric value.

The mean fiber concentration for Run 2 was 0.46 f/cc, with an SD of 0.17. The eight-hour TWA for fibers in Run 2 was 0.05 f/cc.

All fiber data points from Runs 3 and 4 were combined to produce a mean of 0.19 f/cc and an SD of 0.17. Utilizing Runs 3 and 4 to most reliably reflect the potential airborne asbestos exposure to the operator during a workday, the 8-hour TWA for fiber concentration was 0.05 f/cc.

Total and respirable dust concentrations, similar to the airborne fiber results reported above, were not significantly different. Therefore, these data were combined to produce a mean, SD, and eight-hour TWA. As before, values reported as "less than" numbers were divided by 2 for data analysis.

Run 2 produced a dust concentration mean of 0.58 mg/m^3, with an SD of 0.09. The 8-hour TWA for Run 2 was 0.05 mg/m^3. Data from Runs 3 and 4 were combined, resulting in a dust concentration mean of 0.21 mg/m^3, with an SD of 0.08. The combined 8-hour TWA for Runs 3 and 4 was 0.16 mg/m^3.

Clothing Study

In the experiment to determine the quantity of fibers that remained on the operator's clothing, the airborne fiber concentration generated from the agitation of the operator's coveralls was 0.72 f/cc during the 30 minutes of testing. Background concentration in the laboratory was determined to be <0.065 f/cc. The analyst reported the presence of a variety of fiber types in the sample; however, only small portions of these were considered to be asbestiform. The asbestiform fibers present in this sample were determined to be chrysotile.

DISCUSSION

The vehicular brake service monitoring described in this investigation (Phase 1 Tests) support that service workers are not exposed to quantities of asbestos fibers in excess of acceptable standards based on TWA of fiber concentrations in the environment. Eight-hour TWA levels are well below current regulatory requirements for the workplace. This is true whether or not the worker used compressed air to remove accumulated road and brake dust. These data are in accord with the results of various investigators in the U.S. as well as in other locations.[4,7,10]

Hatch[4] reported on airborne asbestos concentrations released during the cleaning of brake drums using compressed air jets, with results ranging from 2.1–8.2 f/cc with a 10-minute average of 0.8 f/cc. Likewise, Paik and Lee[7] reported on a variety of activities, including grinding, assembling, brushing, and cleaning with compressed air, which resulted in airborne asbestos concentrations ranging from 0.01–7.28 f/cc. Sheehy of NIOSH[10] reported a range of <0.003–0.166 f/cc during brake repair operations.

Even those rare fibers that escape destruction during brake application apparently do not represent an important source of exposure (see Figure 3). Figure 4 is a photomicrograph of the residue from a drum showing considerable nonfiber particulate similar to that reported by Lynch in 1968.[11] There were very few fibers in this residue, with most of the fiber-like structures observed less than 3 microns in length. The fibers depicted in Figures 2 and 3 show what appears to be phenolic resin residue deposited along their length. The presence of residue on such a fiber is reasonable based on the consideration that the phenolic resin that forms the basic structure of a brake shoe pad must bond tightly to each fiber in the matrix. If this were not so, the pad could not hold together during the many cycles of heating and cooling required during the life of the pad.[4]

A fiber with resin deposits along its length will have different aerodynamic characteristics (i.e. a larger aerodynamic diameter) compared with an otherwise clean fiber of similar size. Such a fiber would be expected to either not gain entry into the respiratory system or have a greater opportunity to deposit higher in the system where there is limited retention.[28–30]

Independent from the fiber level results, the real-time gravimetric analysis of the dust in the area of the brake service worker offers strong support for a contention that dust, and presumably any residual asbestos fibers, does not remain in the breathing zone of the worker for an extended interval.

In the first and second runs of the Phase 2 investigation, the work activities of the operator were constrained to reproduce the arc grinding process of an 8-hour day into approximately 40 minutes. This work was conducted in rooms with essentially no detectable air movement (i.e. <2 m/sec). In the normal shop circumstance, arc grinding is conducted for up to possibly 5 min/hr. This intermittent use of the arc-grinding machine gives the environment an opportunity to dissipate any fibers that may be generated. Therefore, the conditions of the present experiment should be considered as a worst-case scenario.

In the third and fourth runs of Phase 2, the activities most closely simulate the normal functioning of a busy brake service/arcing machine operator throughout a workday. The assumption of this present study design was that twice as many drum and brake jobs could be accomplished in an 8-hour day as is typical for a normal shop; therefore, the conditions of the present series of experiments should also be considered a worst-case scenario.

The Permissible Exposure Limit (PEL) as promulgated by OSHA (July 1, 1999) for asbestos is a TWA of 0.1 f/cc, with an excursion limit of 1.0 f/cc for a monitoring period of 30 minutes.[31] Results of the investigation reported herein suggest that even in a busy shop, a worker would be expected to have been exposed to concentrations of fibers at a concentration considerably less than the PEL for asbestos.

In regard to nuisance dust, OSHA's PEL for total dust is 15 mg/m^3 with a respirable fraction concentration of 5 mg/m^3. Total and respirable dust concentrations in the Phase 2 portion of our study were less than 10% of OSHA's current acceptable limits.[26]

Occasionally, questions are raised regarding "take-home" exposures due to fibers generated in a worker's environment. The concern is that fibers attach to the worker's clothing and are carried home, thus exposing the various members of the household. In particular, there is concern regarding those individuals handling the clothing to remove excess dust prior to laundering. The results support little reason to conclude that the persons handling such clothing might be exposed to chrysotile fiber concentrations above the acceptable standards. The majority of fibers found in this study were not asbestiform, but other types of benign fibers such as cotton, etc.

CONCLUSIONS

Phase 1

The results of this investigation clearly support a contention, in agreement with the epidemiological literature, that during the years where asbestos-containing brakes were utilized, brake service workers were not exposed to levels of asbestos fibers in excess of currently acceptable workplace concentrations.

Phase 2

Essentially, the analyses of the environment of such work support that a small quantity of chrysotile is released into the air during the process of arc grinding. However, when this equipment is utilized in a manner consistent with the manufacturer's design, there is little or no basis to conclude that excessive asbestos concentrations will be generated.

In summary, based on the data provided in this study, it is reasonable to opine that the process of arc grinding brake shoes under conditions consistent with those described herein would not expose the operators, or those working nearby, to concentrations of chrysotile fibers in excess of currently acceptable standards.

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24. SKC Respirable Dust Aluminum Cyclones, Model Numbers 225-01-01 (for 25 mm cassette respirable asbestos samples) and 225-01-02 (for 37 mm respirable dust samples); SKC Gulf Coast Inc., 9827 Whithorn Drive, Houston, TX 77095.
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