FILE NAME: Packings and Gaskets (PAG)

DATE: 2000

DOC#: PAG017

DOCUMENT DESCRIPTION: Journal Article - Exposures to Asbestos Arising from Bandsawing Gasket Material

Applied Occupational and Environmental Hygiene
Volume 15(5): 404–408, 2000

1047-322X/00 $12.00 + .00

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Exposures to Asbestos Arising from Bandsawing Gasket Material

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A simulation of bandsawing sheet asbestos gasket material was performed as part of a retrospective exposure evaluation undertaken to assist in determining causation of a case of mesothelioma. The work was performed by bandsawing a chrysotile asbestos (80%)/neoprene gasket sheet with a conventional 16-inch woodworking bandsaw inside a chamber.

Measurements of airborne asbestos were made using conventional area and personal sampling methods, with analysis of collected samples by transmission electron microscopy (TEM) and phase contrast microscopy (PCM). These were supplemented by qualitative scanning electron microscopy (SEM) examinations of some of the airborne particles collected on the filters. In contrast with findings from studies examining manual handling (installation and removal) of gaskets, airborne asbestos concentrations from this operation were found to be well above current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) (eight-hour time-weighted average [TWA]) and excursion limit (30-minute) standards. Although some "encapsulation" effect of the neoprene matrix was seen on the particles in the airborne dust, unencapsulated individual fiber bundles were also seen. Suggestions for the implications of the work are given. In summary, the airborne asbestos concentrations arising from this work were quite high, and point to the need for careful observation of common sense precautions when manipulation of asbestos-containing materials (even those believed to have limited emissions potential) may involve machining operations.

Keywords Asbestos, Gasket, Bandsaw, Exposure

An industrial hygiene evaluation was undertaken of the lifelong asbestos exposure of a plaintiff who had filed a lawsuit against a number of defendants formerly or currently involved in the manufacture or distribution of asbestos-containing materials. The plaintiff had been diagnosed with pleural mesothelioma. Among other jobs over his lifetime, the plaintiff had been assigned to work by one of his employers in the 1960s that involved the bandsawing of large numbers of gaskets from sheets of a neoprene-impregnated gasket material. These gaskets were stacked to form a thick layer of insulation for a specific piece of heating equipment used in the aerospace industry during certain kinds of engine tests.

No reports of similar work were found in the industrial hygiene literature, although several reports of exposures during conventional manual handling (installation and removal) of single gaskets from piping and ancillary fittings were identified.[1–4] In some of these there were some discussions of the impact of machining work, with a few measurements, but with no specific testing of bandsawing. Accordingly, a simulation of this specific task was undertaken to fill this gap, because the same gasket used by the plaintiff was found to still be available commercially.

The primary issue in question was the probable asbestos exposure of the plaintiff during this specific job. A secondary issue was the condition of the airborne particles, because some experts retained by one side or the other in the asbestos litigation have opined that matrices such as the neoprene in this gasket will "encapsulate" fibers and fiber bundles, thus preventing biologically harmful exposure. Other experts, of course, have different opinions.

METHODS AND MATERIALS

The material examined was a neoprene-impregnated sheet gasket, 0.3175 cm (1/8 inch) thick. The asbestos content of the gasket as stated by the manufacturer was 80 percent chrysotile. The gasket was delivered from the manufacturer as a tightly rolled 101.6×365.76 cm (40×144 inches) sheet in corrugated paper wrapping. The outer wrapping bore a warning label as shown in Figure 1. (Note that the label warnings specifically proscribe sawing as performed here.) Cutting of the sheet to convenient size for bandsawing (101.6×60.96 cm—40×24 inches) was performed with a Sears Craftsman saber saw, with a conventional wood sawing blade ($\sim$4 teeth/cm $\approx$ 10 teeth per inch—tpi). The bandsawing was done with a Reliant Model EE 166 16 inch (40.64 cm) wood-cutting bandsaw, with the original blade

WARNING

(NAME) COMPRESSED ASBESTOS GASKET MATERIAL

This product contains asbestos and has been defined by the EPA as Category I NONFRIABLE asbestos containing material. In order to effect a clean cut, smooth edge on the gasket, and to minimize dust created in cutting, we recommend that all cutting equipment such as dies, shears, strippers, snips and blades, etc. be maintained as sharp as possible. Avoid drilling, grinding, sawing, sanding, or other dust producing processes. After use, remove gaskets from flanges with an approved gasket removal agent.

(NAME) MANUFACTURING COMPANY
Address

FIGURE 1
Warning label on roll of sheeting—original size and typography.

supplied by the manufacturer (approximately 3 teeth/cm $\approx$ 7 tpi) operated on the middle speed (609.6 cm/sec = 1200 feet/minute) of the three available on the saw.

The work was done inside a specially constructed chamber built of 0.01524-cm-thick (= 0.006 inch—"6 mil") polyethylene sheeting walls, with a double layer of 0.0254 cm (10 mil) polyethylene for the floor. The chamber was constructed with a large work area chamber (363.2 cm L $\times$ 188 cm W $\times$ 269.2 cm H = 18.38 m^3 = 143″ L $\times$ 74″ W $\times$ 106″ H $\approx$ 649 cubic feet), and an entrance divided into two smaller chambers. The two smaller chambers were a "clean room" leading from the main laboratory area, which led into a "dirty room" or "equipment room" leading into the work area chamber. Each small entrance chamber was approximately 102 cm $\times$ 127 cm $\times$ 269 cm (40″ $\times$ 50″ $\times$ 106″). The entire chamber was ventilated during all sawing by drawing air into the entry of the clean room with a Nilfisk Model GS 80 HEPA-filtered vacuum cleaner placed at the end of the chamber farthest from the entry. The air flow rate was approximately 0.99–1.13 cubic meters per minute (35–40 cubic feet per minute), for an air exchange rate of 3.2–3.7 air changes per hour (ACH). All sawing work was done by the author, wearing disposable garments over street clothes, and a properly fitted half-mask respirator with HEPA filter cartridges. It is noted that this level of protection does not meet the modern protective measures required by the Occupational Safety and Health Administration (OSHA) for cutting asbestos-containing materials. Please refer to the conclusions for recommendations for personal protective measures for this work.

Three types of sawing were done. First, the large roll of stiff material was cut with a saber saw to reduce the pieces for test to approximately 61 cm $\times$ 102 cm rectangles. Secondly, the large rectangles were cut on the bandsaw to smaller rectangles, each about 12 cm $\times$ 15 cm. Thirdly, each of the smaller rectangles was cut in half on the bandsaw. All sawing was of single thicknesses of the gasket material.

Air samples were taken during the work as personal breathing zone samples and area samples. The samples were taken by drawing air through mixed cellulose ester filters in three-piece conductive air sampling cassettes (25 millimeter diameter, 0.45 micrometer nominal pore size, 2-inch cowl) obtained from Safety Environmental Control, Inc. (Keene New Hampshire) (Catalog # 203000182, Lot # 9601081). The personal samples were taken with SKC battery-operated sampling pumps at flow rates of 2.0 and 2.55 liters per minute. The area samples were taken with Dawson 110 volt pumps operated at 11.5 and 10.85 liters per minute. Each sampling train was calibrated before and after each sample by determining the total volumetric flow rate through the train with a rotameter (calibrated less than one month prior to the evaluation with a Spectrex BFM 4000 primary volumetric standard).

The personal breathing zone samples were taken by placing the sampling cassettes in the author's breathing zone (clipped to his clothing so that the opening was near his nose and mouth). The area sampling locations were at breathing zone height (152–183 cm above floor level) with one placed to the left of the bandsaw in the pathway between the saw and the exhaust inlet and the other placed behind the bandsaw in a location undisturbed by either the sawing or the air flow. Both were approximately 60–90 cm horizontally from the bandsaw blade.

Three sets of samples were taken. During the saber saw cutting to reduce the sheet to manageable-size pieces for bandsawing, a single personal sample (A) was taken from the right side of the operator's breathing zone. The second set of samples was taken during the cutting of the two large pieces to smaller pieces (approximately 12 cm $\times$ 15 cm). (samples B to E.) That cutting was interrupted by a power failure for a few minutes, as indicated on Table I. The third set of samples was taken during the cutting (for a few minutes) of the 12 cm $\times$ 15 cm pieces into halves. (samples F to J, no G used.)

Each filter was analyzed by phase contrast microscopy (PCM).[5] Each was also evaluated for its suitability for further analysis by transmission electron microscopy (TEM).[6] All except two samples (D and E) were deemed to be suitable for such analysis. Samples D and E were too heavily loaded for direct analysis. Rather than prepare the samples for analysis by an indirect preparation method with consequent splitting of fiber bundles and "magnification" of the asbestos structure counts, the samples were not further analyzed. In addition, some particles from the samples were examined by scanning electron microscopy (SEM),[7] and photomicrographs were taken to illustrate the condition and character of the particles collected (see Figures 2 and 3 for examples).

RESULTS

The results are shown in Table I. The personal exposures to fibers longer than 5 micrometers (μm) during bandsawing were between 2.2 and 4.9 fibers per milliliter (f/mL) by PCM where the current OSHA eight-hour TWA standard is 0.1 f/mL, and the 30-minute excursion limit is 1.0 f/mL. The personal results by TEM were higher; 22.2–49.3 asbestos structures per milliliter

TABLE I

Exposures to airborne asbestos fibers and structures during sawing of 1/8-inch asbestos sheet gasket

							Concentrations		
Sample #	Time	Activity	Area/ personal	Location	Duration (minutes)	Volume (liters)	PCM f/mL	TEM (total) s/mL	TEM (>5 μm) s/mL
A	1321–1333	Saber sawing/ flattening sheet	Personal	R. side BZ	12	24	<0.11	0.62	0.21
B	1510–1519 1524–1545	Bandsawing	Personal	R. side BZ	30	60	3.1	22.2	8.2
C	1510–1519 1524–1545	Bandsawing	Personal	L. side BZ	30	76.5	2.2	26.4	9.7
D	1511–1515 1524–1545	Bandsawing	Area	Back of saw	25	287.5	0.75	Overload	Overload
E	1511–1515 1524–1545	Bandsawing	Area	Side of saw	25	271.3	0.96	Overload	Overload
F	1555–1601	Bandsawing	Area	Back of saw	6	69	1.8	14.3	5.7
H	1555–1601	Bandsawing	Area	Side of saw	6	65.1	2.3	22.7	7.6
I	1555–1602	Bandsawing	Personal	R. side BZ	7	14	4.9	49.3	17.6
J	1554–1602	Bandsawing	Personal	L. side BZ	8	20.4	3.1	43.5	9.7

FIGURE 2
Scanning electron micrograph @ 500x showing mostly unencapsulated fibers.

FIGURE 3
Scanning electron micrograph @ 450x showing many encapsulated fibers.

(s/mL) for all asbestos structures and 8.2–17.6 s/mL for those asbestos structures longer than 5 μm. The area samples showed results somewhat lower than the personal samples, as would be expected. For the PCM analyses, the area sample results were between 0.75 and 2.3 f/mL. The TEM area results were 14.3 and 22.7 s/mL for total structures, and 5.7 and 7.6 s/mL for those structures longer than 5 μm in the two samples that could be analyzed.

DISCUSSION

The concentrations of airborne fibers longer than 5 μm measured (by PCM) in the breathing zone of the operator during bandsawing of this material are well above the current OSHA Permissible Exposure Limit (PEL) eight-hour TWA standard for occupational exposure to asbestos of 0.1 f/mL, and the OSHA 30-minute excursion limit of 1.0 f/mL. For the area samples taken close to the bandsaw, the concentrations were all well above the TWA PEL, and two of four were above the excursion limit as well. (The other two samples, at 0.75 and 0.96 f/mL, were near to the excursion limit.) The concentrations of asbestos structures measured by TEM (both total and those larger than 5 micrometers in their longest dimension) were well above the fiber concentrations measured by PCM, and were significant and substantial. The concentrations of airborne fibers/structures determined from the filters with the highest surface loadings of fibers and asbestos structures were lower than for those taken in the same general locations, but which had lower loadings. This may indicate that there was some obscuration of asbestos particles by overlying particles in the more heavily loaded samples, and that these results may therefore understate the actual concentrations. The air flow through the chamber (3.2–3.7 ACH) was higher than is sometimes found in machine shops or other similar settings, and thus these results may understate actual potential exposures for this reason as well. However, the fact of enclosure will act to restrict dilution, and the concentrations reported here may thus be higher than would be expected in a "real life" setting.

As can be seen in Table I, the saber sawing did not produce PCM-measureable airborne asbestos. However, the detection limit of the method was relatively high because of the short sampling period, and relatively low concentrations were measured by TEM. Based on the ratios of total and >5 μm TEM structures to PCM fibers in the other sets of samples, it is estimated that the PCM concentration in Sample A would have been in the range of 0.04–0.09 f/mL, if a sufficient air volume had been collected.

The periods of exposure at the measured concentrations that would have been required to exceed the OSHA standards using the PCM personal BZ results have been calculated for the extremes of the range of those measurements. If one was exposed to a concentration of 2.2 f/mL, a period of approximately 22 minutes would suffice to produce an eight-hour TWA exposure of 0.1 f/mL, with no other exposure. For 4.9 f/mL, only about 10 minutes would be required. With regard to the 30-minute excursion limit of 1.0 f/mL, 14 and 6 minutes would be required to exceed it at 2.2 and 4.9 f/mL, respectively. If the maximum concentration found for the TEM >5 μm personal BZ measurements (17.6 f/mL) was similarly considered, less than 3 minutes would be required to exceed both the PEL and the excursion limit.

The findings here are reasonably consistent with the findings of others[1,4] who have studied asbestos exposures during gasket handling involving machining of gaskets. That is, that power machining (wire brushing old gaskets with a wire disc grinder to remove adherent material from the gasketed surface is the most common machining operation) may generate appreciable concentrations of airborne asbestos fibers (in the range of ~0.5–5.0 f/mL by PCM), although normal hand cutting does not usually cause such high concentrations.

As can be seen in Figures 2 and 3, there is support for both sides in the "fiber encapsulation" dispute. Some of the fibers and fiber bundles do appear to be largely encapsulated by the amorphous neoprene matrix. However, some others are not, and one can easily see asbestos fiber bundles that are free of the neoprene. Those figures also, however, show that at least some of the fibers are agglomerated into large particles that could not, under any reasonably foreseeable set of circumstances, be considered respirable.

Even though the hand cutting or other manual handling of this or similar products cannot be guaranteed free from significant risk of asbestos exposure, the importance of observing label instructions is illustrated here. Any machining operation on any asbestos-containing product may be accompanied by the production of excessive concentrations of airborne asbestos, if sufficient energy is applied to the product. Another way of expressing this is to state that "friability" is always relative to the energy applied.

Finally, this material was purchased for this study in October, 1996. Accordingly, users of gaskets are warned that asbestos is not a material of the past, but is available on the open market today. Given the concentrations measured here, and the comparability of these results with measurements of others, it will be important to verify that appropriate precautions are taken to prevent exposure to asbestos, if this or similar products are viewed as being so essential that a non-asbestos substitute cannot be used in their place.

CONCLUSIONS

Based on this study, it appears likely that similar usage of this or similar sheet gaskets may have caused significant asbestos exposures during its past and current applications. It is unknown how frequently such work was done (or is being done now), although it has not been reported previously. However, if many duplicate gaskets were or are to be produced, the possibility of bandsaw usage should be investigated, because the expected asbestos concentrations from such usage will be orders of magnitude above those generated by hand work.

The most desirable control will be to disallow the use of this or any similar asbestos gasketing material in the workplace. Where it must be used, the label restrictions given in Figure 1 should be observed, at a minimum. If machining such as that reported here is expected, it is recommended that controls similar to those used in this study (negative pressure enclosure, supplemented by respiratory protection and protective clothing) should be the minimum requirements. Where similar kinds of activities are carried out in a workplace setting, the requirements of the OSHA asbestos regulations[8] should be carefully followed. Conventional local exhaust ventilation and enclosure will almost certainly be the most effective control measure, if properly designed and implemented. Because of the concentrations found here, the relevant OSHA personnel should be consulted to approve the measures to be taken.

Based on the TEM concentrations reported here (up to almost 50 s/mL for total structures, and up to almost 18 s/mL for those >5 μm) pressure demand supplied air systems would appear to be the only appropriate respiratory protection. Even if the PCM results are accepted as an appropriate index of risk, and it is assumed that respiratory protection allowing in-mask concentrations as high as 0.01 f/mL may be used, some form of supplied air system will be required to meet the implicit protection factor requirement of $\sim$500. Of course, if it is assumed that the most appropriate workplace exposure standard for asbestos is the usual ambient concentration, then a protection factor of $>$5000 will be needed to make the in-mask concentration 0.001 f/mL or below, to meet today's ambient concentrations. Clearly, substitution is the most desirable control, and prohibition of power machining would be next most desirable.

ACKNOWLEDGMENTS

The original work was funded by the law firm of Galiher, DeRobertis, Nakamura, and Ono of Honolulu, Hawaii, representing the plaintiff and his family. The laboratory analyses were performed by Bernard Thomas of the R.J. Lee Group, Inc. in San Leandro, California.

REFERENCES

1. Cheng, R.T.; McDermott, H.J.: Exposure to Asbestos from Asbestos Gaskets. Appl Occup Environ Hyg 6(7):588–591 (1991).
2. McKinnery, W.N.; Moore, R.W.: Evaluation of Airborne Asbestos Fiber Levels During Removal and Installation of Valve Gaskets and Packing. Amer Ind Hyg Assoc Journ 53(8):531–532 (1992).
3. Spence, S.K.; Rocchi, P.S.J.: Exposure to Asbestos Fibers During Gasket Removal. Ann Occup Hyg 40(5):583–588 (1996).
4. Liukonen, L.R.; Still, K.R.; Beckett, R.R.: Asbestos Exposure from Gasket Operations. Industrial Hygiene Branch, Naval Regional Medical Center, Bremerton, WA (May, 1978).
5. National Institute for Occupational Safety and Health (NIOSH): Asbestos and Other Fibers by PCM—Method 7400. NIOSH Manual of Analytical Methods—4th Edition, DHHS (NIOSH) Publ. No. 94-113. NIOSH, Cincinnati, OH (1994).
6. Environmental Protection Agency (EPA): Asbestos-Containing Materials in Schools; Interim Transmission Electron Microscopy Methods. Title 40, Code of Federal Regulations, Part 763, Subpart E, Appendix A (1987).
7. R.J. Lee Group, Inc.: Personal SEM, v. 3.11. R.J. Lee Group, Monroeville, PA (1996).
8. Occupational Safety and Health Administration (OSHA): Asbestos. Construction Standard, Title 29, Code of Federal Regulations, Part 1926.1101; General Industry Standard, Title 29, Code of Federal Regulations, Part 1910.1001 (1999).