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Releasability of Asbestos Fibers From Asbestos-Containing Gaskets

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Gaskets must be considered during reinspections under the Asbestos Hazard Emergency Response Act (AHERA). Maintenance operations on gaskets may release asbestos fibers exceeding 1 f/cc. Therefore, precautions should be taken during this type of work.

Under the Asbestos Hazard Emergency Response Act (AHERA), the Local Educational Agencies (LEAs) must conduct reinspections every three years of all "friable and nonfriable known or assumed ACBM." Among the materials that the LEAs are to consider for reinspection are "other materials such as boiler fire brick, gaskets, and caulking which may have been missed." If an inspector overlooked a suspect material during the original AHERA inspection, there is no specific requirement that it be included in the reinspection. However, any missed actual or suspect ACBM present in the school represent a violation of AHERA for which both the LEA and the original inspector could be liable.[1]

Gaskets represent an asbestos-containing material (ACM) which is somewhat different from the surfacing material easily observable in an asbestos survey. The term "gasket" is a general term for a number of sealing materials, including sheet gaskets, packing and asbestos rope. This paper presents information primarily about sheet gasket materials. Packing is often found inside valve systems and asbestos rope has been used on boiler and furnace doors.

Although replacement sheet gaskets may be found in a storage closet, in service gaskets of this type are generally located between two pipe flanges and are not readily accessible for disturbance. The concern over asbestos-containing gaskets is derived principally from maintenance issues. Periodically a pipe connection must be broken at the flanges and the old gasket removed and replaced. This effort may require a simple scraping with hand tools or may need the assistance of power tools to clean the flange. Possible fiber release from both cutting new gasket material and from the removal of after service gasket

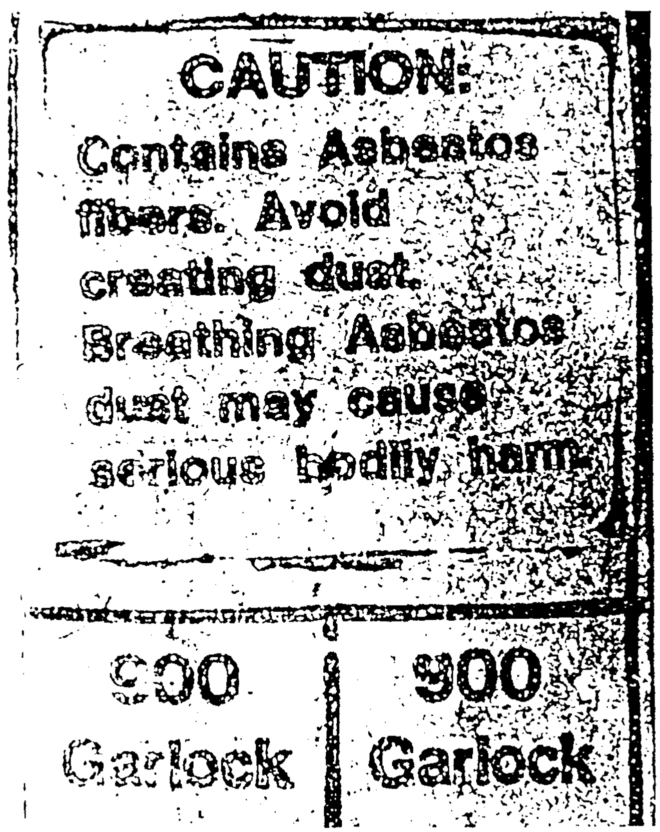

Figure 1. Warning Label on a piece of asbestos-containing sheet gasket material.

material as well as the debris from these activities must be considered. This paper provides information about the release of asbestos from sheet gasketing material, referred to as "gaskets" in many instances in the remainder of the paper.

Gasket Materials

In buildings, sheet gasket materials are used mainly to seal pipe joint connections and prevent leakage of fluids between the solid surfaces of the pipe flanges. They are used in steam lines and in some water pipelines. Gaskets, often consisting of more than 70 percent chrysotile asbestos, are used against alkaline, neutral or weak acid solutions. Crocidolite (blue asbestos) containing gaskets have been used against harsher acid solutions. Sheet gaskets are composed of chrysotile asbestos compressed into a sheet with styrene butadiene rubber or other binder.[2] Other organic binders used in making asbestos gaskets include natural rubber, buna-S and buna-N synthetic rubbers, or neoprene.[3] In their original state, asbestos-containing sheet gasket materials which are composed of asbestos in an organic binder are not considered friable. However, gasket material after service may be dry and friable.

Under 1992 U. S. Environmental Protection Agency (EPA) NESHAP regulations, gaskets are included in Category I nonfriable asbestos-containing material (ACM) along with packings, resilient floor covering, and asphalt roofing products.[4] In most cases the asbestos NESHAP does not require their removal prior to demolition. Removal prior to demolition would be required if the gaskets or other Category I nonfriable ACMs became regulated asbestos-containing material (RACM) because they have been subjected to sanding, grinding, cutting, or abrading. Removal would be necessary before demolition if the gaskets (Category I nonfriable ACM) were located in a structure which was to be demolished by burning.

In the Occupational Safety and Health Administration (OSHA) regulations, asbestos-containing gaskets are included under Class II asbestos work which pertains to activities involving the removal of ACM which is not thermal system insulation or surfacing material.[5]

According to the OSHA rules and regulations, when removing gaskets containing ACM, the employer shall ensure that the following work practices are followed: (A) if a gasket is visibly deteriorated and unlikely to removed intact, removal shall be undertaken within a glovebag. (B) the gasket shall be thoroughly wetted with amended water prior to its removal. (C) the wet gasket shall be immediately placed in a disposal container. (D) any scraping to remove residue must be performed wet.

Gaskets would also be covered in Class IV asbestos work. Class IV work includes maintenance activities during which employees contact ACM and custodial activities in which employees clean up waste and debris containing ACM. Under the Class IV activities, dry sweeping, shoveling or other dry clean-up of dust and debris containing ACM is prohibited, regardless of measured levels of asbestos exposure or the results of initial exposure assessments.

Hazard Communications Labels

In accordance with OSHA's Hazard Communication Standard, labels shall be used to identify asbestos containing material. The labels shall contain a warning statement against breathing asbestos fibers. However, labels are not required when asbestos fibers have been modified by a bonding agent, coating, binder, or other material, provided that the manufacturer can demonstrate that, during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation; no airborne concentrations of asbestos fibers in excess of the permissible exposure limit and/or excursion limit will be released.[6] While some manufacturers of gaskets represent that the asbestos is completely bound or encapsulated in their gaskets and therefore need no hazard label, others have put warning labels on their gaskets as shown in Figure 1.

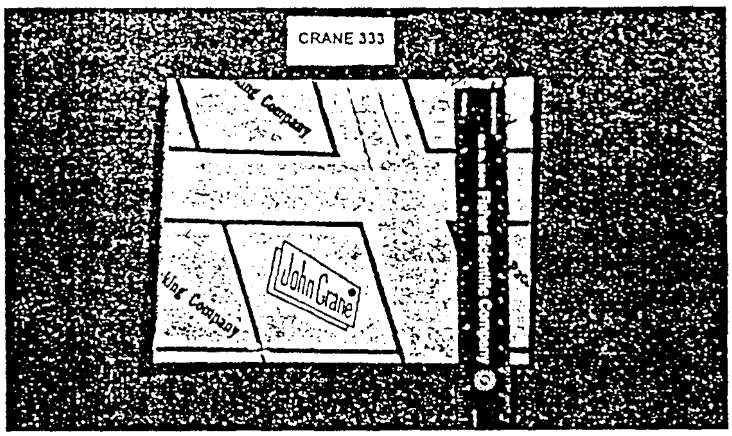

Fig. 2. Asbestos-containing sheet gasket material of the type from which gaskets could be cut for sealing pipe flanges.

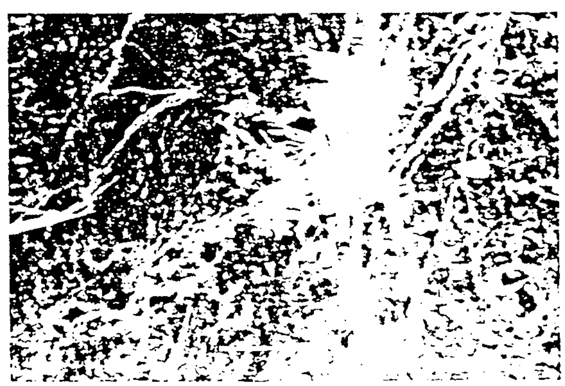

Fig. 3. Close-up view of the surface of the gasket material from Fig. 2 showing uncoated chrysotile asbestos fibers protruding.

Encapsulation or Releasable Fibers

The question of whether or not all asbestos fibers are completely bound or encapsulated in gasketing material is one that has been studied by microscopy.[7] A close examination of the surfaces of four unused gaskets showed that although most of the asbestos is indeed bound within an organic binder, uncoated asbestos fibers were present on the surface and on the edges of the gaskets which would be released as free fibers with mild abrasion. Additional work examining gaskets from a number of manufacturers showed similar results. A portion of a John Crane, Crane Packing Company, sheet gasket labeled 333 HEAVY DUTY is shown in Figure 2. A magnified view of the surface of the top of the gasket is shown in Figure 3. The

Table 1. Summary of Air Sampling Results for Gasket Activities

Activity	PCM* (f/cc)
Cutting	
Hand punching (no controls)[8]	3.0-5.0
Hand & machine processing (controls)[8]	0.01-1.3
Cutting with knives, power shears, wheels[10]	0.001-0.017
Cutting with saber saw/power shear and wheel cutter[10]	0.33-0.49
Installation	
Installation[8]	<0.03
Installation (following removal of old gasket)[11]	0.13-0.19
Removal	
Removal[11]	0.049-0.44
Hand scraping[10]	up to 0.4
Dry removal with scraper/wire brush[10]	0.11-0.33
Dry polishing of flange[10]	1.4
Wet removal[10]	<0.06
Cleaning	
Cleaning of debris following removal (no controls)[9]	0.05
Shearing and punching activities with cleanup[9]	1.2 & 1.67

chrysotile fibers are uncoated and protruding from the gasket surface.

Gasket Fiber Release Studies Reported in the Literature

A government sponsored report on the exposures from gasketing operations was compiled by the GCA Corporation in 1982.[8] They summarized their findings on gaskets as follows: Secondary processing of compressed sheet gaskets can result in comparatively high workroom fiber concentrations, on the order of 3.0 to 5.0 f/cc during hand and machine punching, if control measures are not employed. When dust control procedures are implemented, which is usually the case, fiber concentrations resulting from various hand and machine processing steps and materials handling operations range from less than 0.01 to 1.3 f/cc. Measured airborne fiber concentrations resulting from the installation of compressed sheet gaskets were less than 0.03 f/cc as reported by one study. Removal of these materials, however, can result in higher concentrations, up to 0.4 f/cc during hand scraping of material adhering to a bearing surface. In this latter case, fiber release is related to the physical exertion required to remove the material and to the high asbestos content (equal to or greater than 75 percent) of compressed sheet gasket.

The information in the GCA report is apparently based primarily on a Naval Regional Medical Center report commonly referred to as the Bremerton study.[9] Air samples were collected during gasketing activities including gasket handling, installing, removal and disposal at the Puget Sound Naval Shipyard. In addition to the summary provided by the GCA Corporation, data on cleaning of gasket debris showed less than 0.05 f/cc in one cleanup following removal with no controls and 1.2 f/cc and 1.67 f/cc during shearing and punching activities which included cleanup.

Data published in the scientific literature on asbestos exposures during use and handling of asbestos gaskets in the oil and chemical industries showed a range of fiber levels depending on the activity.[10] Longterm samples (over 300 minute sampling periods) during gasket fabrication with knives, power shears, and a wheel cutter showed levels ranging from 0.001 to 0.017 f/cc. Short term samples (30-55 minutes) collected while the gaskets were cut with a saber saw or power shear and wheel cutter showed concentrations ranging from 0.33 to 0.49 f/cc. Short-term exposures during dry removal of gaskets varied between 0.11 and 0.33 f/cc when surface cleaning was done with a scraper and/or with a wire brush. One air sample, collected during dry polishing of pipe flanges with a power sander, showed 1.4 f/cc for the task. A wet-work method for the removal of after-service gaskets which called for the spraying of a solvent-based wetting agent such as an oil to wet the gasket and seating surfaces before removing and cleaning showed workers' short-term asbestos exposures to be below detection (detection limit = 0.06 f/cc). Other published results of simulated gasketing operations showed personal exposure to fiber levels ranging from 0.049 to 0.44 fibers/cc for removal and 0.13 to 0.19 f/cc for installation.[11] TEM analysis of air samples collected during gasket removal and installation showed asbestos fiber levels ranging from 0.86 to 18.44 structures/cc (s/cc) for removal and 0.40 to 74.32s/cc for installation.

As can be seen in Table 1, the scientific literature shows a range of values describing asbestos fiber release from sheet gasket materials. The higher values seem to be related, at least in part, on whether dust control measures were in place and whether power tools were used.

Two studies were performed by the authors to study in a more controlled situation the release of asbestos from gasketing activities primarily from operations using power tools without dust controls and to gain information about the possible releases during the clean-up of debris. The latter question had not been studied independently.

Study I: Removal of Gasket Material and Wire-Brushing of the Pipe Flange

In a controlled area, personal and area air samples were collected before and during the removal of asbestos sheet gasket material and wire-brushing of the pipe flange. Because a maintenance activity often involves the disturbance of more than one material, it is difficult to assess the contribution, if any, of a particular ACM to the overall airborne asbestos concentration. To determine the possible contribution of an asbestos gasket during removal, special precautions were taken to isolate the removal activity from other activities that might have contributed airborne asbestos from other sources. The study was conducted in a warehouse in Norcross, Georgia. An asbestos abatement type enclosure was built for the study to isolate the testing from any other source of asbestos and to prevent any fiber release from contaminating the building.

The containment barriers in the area consisted of three layers of 6-mil polyethylene plastic sheets on a wooden frame and three layers of 6-mil polyethylene plastic on the floor. The containment area (8 ft by 8 ft by 8 ft) was completely contained within a larger containment area. The study area had two high efficiency particulate absolute (HEPA) air filtration devices (AFD) used to clean the area of particulate including asbestos before the gasket removal activity. In the outer area the AFD operated throughout the test. The study consisted of the collection of air samples before and during a gasket removal activity. A valve that had been used in a steam line on-board a ship was used for the experiment. The valve assembly had two sets of flanges with a gasket between each set of flanges. According to the retired steam fitter performing the gasket removal the valve assembly probably carried 40 to 75 pound steam through it. The temperature in the valve could have reached about 160° C. Gaskets were removed from both sides of the valve. The gaskets were not wetted before removal.

Prior to starting the study, three (3) area air samples were collected to determine the background level of asbestos in the air of the study area. The air was stirred aggressively with a broom and the drill (power wire brush) was operated. The drill was a Campbell Hausfeld Model TL1006 air pressure powered drill that has a maximum speed rating of 2500 RPMs. The area sampling cassettes were located on the walls at the breathing zone, five feet from the floor. During the gasket removal activity, personal air samples were collected on the person doing the gasket removal. That person was fitted with two personal air sampling devices.

All personnel inside the study area were protected by respirators and head and body coverings. The decontamination system consisted of a changing room outside the testing area and a clean suit-up room. The decontamination system was used each time a person exited the study area and the overall containment area. The study consisted of four parts. In the first part personal air samples were collected while the worker removed the flange and hand scraped the gasket residue from the flange surfaces as shown in Figure 4. In the second part new personal air monitoring cassettes were placed on the worker and he cleaned the flange face with power brushing equipment as shown in Figure 5. In the third part, the worker wearing a new set of air monitoring cassettes removed the flange on the other side of the pipe valve and removed the old gasket by hand scraping and then power brushed the flanges. In the fourth part, the worker again wearing a new set of air monitoring cassettes swept the floor in the containment with a broom.

Air samples were analyzed by the standard phase contrast microscopy (PCM) method NIOSH 7400 using the "A" counting rules. Although the phase contrast microscope enhances the

Table 2. Summary of Personal Air Sampling Results for Gasket Removal (Study 1)

Activity	PCM* (f/cc)	TEM** (s/cc)
Background	0.004	<0.02
Hand scraping	0.14	3.9
Power wire brushing	6.8	62
Hand scraping and power wire brushing	2.1	20
Broom sweeping of area after removal	5.5	44

* Phase Contrast Microscopy counts fibers greater than 5 μm in length and greater than 0.25 μm in diameter.

** Transmission Electron Microscopy identifies and counts asbestos structures containing fibers greater than 0.5 μm in length and greater than 0.02 μm in diameter.

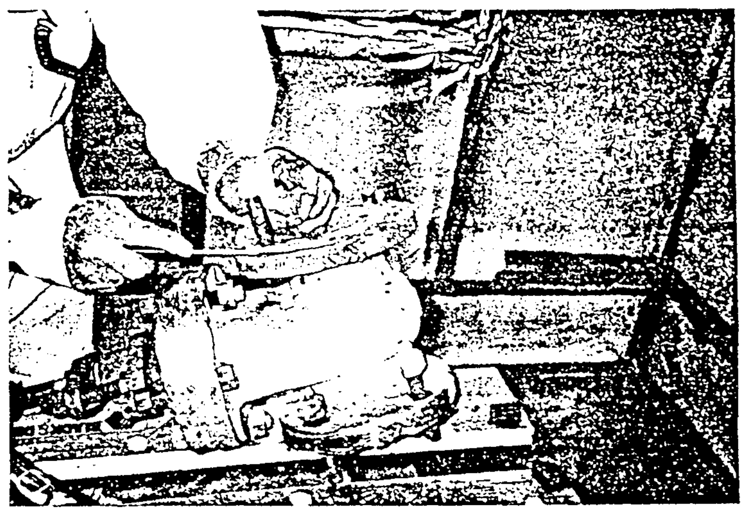

Fig. 4 (top): Removing an after service asbestos-containing gasket from a pipe flange by hand-scraping.

Fig. 5 (left): Power wire brushing of a pipe flange after removal of the gasket during Study 1.

analyst's ability to see fibers over other types of light microscopes, the standard procedure involves does not involve identification steps which specifically determine how many of the fibers counted are actually asbestos. Because sheet gasket material may contain other types of fibers, some of the samples were prepared for further study by transmission electron microscopy (TEM). The samples were prepared and analyzed using the International Standards Organization (ISO) direct preparation counting procedure. This TEM analysis method identifies asbestos fibers on the basis of morphology, crystal structure and X-ray elemental analysis. All asbestos fibers longer than 0.5 µm were counted by TEM so that a total asbestos concentration could be determined. Both personal samples were analyzed by both PCM and TEM.

Polarized light microscopy (PLM) was used to determine the type of asbestos in the sheet gasket material. A friability test was performed on the samples of gasket material removed from the flanges.

Results

The results of the personal air monitoring are shown in Table 1. Chrysotile fibers were identified as the primary type of fiber. The TEM fiber counts include structures containing asbestos fibers of any width above 0.5 µm in length. Polarized light microscopic analysis showed the sheet gasket to be approximately 80 percent chrysotile by volume. The gasket materials removed from the valve flanges were friable.

Study 2. Asbestos Fiber Levels Caused by Sweeping of Gasket Debris After Cutting

This study consisted of the collection of air samples during a cleanup of asbestos dust and debris following a cutting of a gasket material with a band saw. Although a saber saw has been reported to be used in the cutting of gasket material, a band saw was used in this case to produce the dust and debris that would be swept up for the study. Air samples were also collected before and during the cutting of the gasket material. The study was conducted in a warehouse area in Norcross, GA in an enclosure as described in Study 1.

Prior to starting the activity, three (3) area air samples were collected to determine the background level of asbestos in the air of the study area. The band saw was operated and the area swept with a broom during the background air sampling.

A dry piece of John Crane (Crane Packing Co.) sheet gasket labeled 333 *heavy duty* was cut with a Craftsman 10-in. band saw for approximately 10 minutes. The air samples for this activity were collected for 18 minutes. The band saw was equipped with a 1/8-in. wide blade which ran at a speed of 1725 RPM. The blade was described as one for smooth-finished straight and curved cuts in material such as wood, plywood, veneer and plastic.

Airborne dust particles were allowed to settle for a period of an hour. Then air samples were collected to establish the air level before clean-up. Samples were collected while the worker swept the containment area with a broom.

During the activities the person doing the cutting and sweeping was fitted with two personal air sampling devices. All samples were analyzed by phase contrast microscopy (PCM) nd some by transmission electron microscopy (TEM).

Analytical Methods

Personal air samples were analyzed by the standard phase contrast microscopy (PCM) method NIOSH 7400 using the "A" counting rules. Some of the samples were prepared for further study by transmission electron microscopy (TEM). The samples were prepared and analyzed using the International Standards Organization (ISO) direct preparation and counting procedure. This TEM analysis method identifies asbestos fibers on the basis of morphology, crystal structure and x-ray elemental analysis. In this study only asbestos fibers longer than 5 µm were counted by TEM.

Polarized light microscopy (PLM) was used to determine the type and amount of asbestos in the gasket material. A friability test was performed on the sample of gasket material before cutting and on the residue after the activity

Results

Polarized light microscopy (PLM) analysis showed the John Crane Gasket to contain approximately 80 percent chrysotile asbestos. As received, the gasket material was not friable. However, it produced dust when scratched. The residue materials from cutting contained dust.

The results of the air monitoring are summarized in Table 3. During cutting with a band saw the asbestos fiber level for the operator was 11 fibers/cc as measured by PCM. TEM analyses of the airborne fiber concentration during band sawing showed a high level of chrysotile asbestos of all widths over 5.0 µm in length. The high number of long, thin asbestos fibers prevented an accurate TEM count. It was estimated that the concentration was over 30 f/cc for asbestos fibers of all widths over 5.0 µm in length.

During sweeping with a broom the airborne fiber level in the vicinity of the breathing zone of the person sweeping was 1.7 fibers/cc. TEM analyses of the airborne fiber concentration during sweeping showed a level of 5.9 s/cc for asbestos fibers of all widths over 5.0 µm in length.

Conclusions

Asbestos sheet gasket, although not considered friable in original, unused condition, can release asbestos fibers into the air during various operations when hand methods are used and especially when power tools are involved. Clean-up following cutting of new gaskets and the removal of after-service gaskets may resuspend dust containing asbestos into the air .

Recommendations

In considering asbestos-containing gaskets during an inspection, reinspection, or other survey; an inspector should begin by checking storage areas for gasket materials labeled with asbestos warnings. The inspector should be aware that not all asbestos-containing sheet gaskets are labeled. Because in-service gaskets cannot be sampled without potentially damaging the piping seal, they should be considered as ACM in the absence of information to the contrary. The results of various tests suggest that asbestos sheet gasket material, although not considered as a friable ACM when new, may become friable. Proper precautions should be taken especially during removal activities. The data presented here emphasize the importance of wetting gasket material before removing or cutting it, as well as the need to avoid sweeping of dry dust and debris. Sweeping dry asbestos-containing dust and debris following cutting or removal of gaskets can cause significant levels of asbestos fibers in the air. ❑

Table 3. Summary of Average Personal Air Sampling Results For Cutting and Sweeping of Sheet Gasket Material (Study 2)

Activity	PCM (f/cc)	TEM (f >5µm/cc)
Background Before Cutting	0.005	BDL (0.004)
During Cutting of the Gasket	11	30*
Background Before Sweeping	0.13	0.37
During Sweeping of Dust & Debris	1.7	5.9

* Estimated. Sample too heavily loaded with thin chrysotile fibers.

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