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Airborne Fiber Exposure Assessment of Dry Asbestos- Containing Gaskets and Packing Found in Intact Industrial and Maritime Fittings

This study assessed airborne fiber exposures from intact asbestos-containing gaskets packings while activities representative of historical work practices were performed. The design eliminated analytical interferences while systematically capturing information related to activity variables. A series of gasket and packing activities was conducted according to traditional methods while sampling was performed to determine the 8-hour time-weighted average (TWA). The fittings used during this study were obtained intact from a decommissioned industrial power plant and U.S. Navy destroyers. The activities tested flat blade scraping, hand wire brushing, power wire brushing, making gaskets with a b hammer, and stem packing removal and replacement. All activities were performed dry for every area and personal sample showed the 8-hour TWAs were well below the current Occupational Safety and Health Administration permissible exposure limit of 0.1 f/cc. A database of more than 400 points was developed to analyze information from variables related to the tests. These factors included, for example, type of gasket, composition of gasket, percentage of gasket adhering to a flange surface, gasket surface area, and time elapsed for removal. The results demonstrate a very low rate of fiber exposure from routine activities associated with asbestos-containing elastomeric gaskets and impregnated packings. **Keywords:** asbestos-containing, exposure assessment, fittings, gaskets, packing, and

Asbestos fiber exposure assessments are difficult to conduct with a high degree of confidence for specific products when either asbestos or nonasbestos fiber contribution from other sources must be carefully managed such that they do not complicate the interpretation of analytical results. Elastomeric gasket and impregnated packing material often contain high percentages of asbestos, and an exposure assessment is difficult to determine in field applications because of the presence of dusts and fibers such as from clothing and other insulating materials such as fiberglass and asbestos.

Assessing the exposures resulting from handling asbestos gasket and packing materials is important because previously installed products are

prevalent and newly manufactured products still used around the world. Gaskets and packings are not banned by the July 1989 U.S. Environmental Agency (EPA) final rule regarding manufacture, importation, processing, and distribution of asbestos products.^{1,2} Asbestos-containing gaskets and packings are the preferred choice in many applications such as chemical plants, refineries, power plants, and ships.

The published literature contains little information representative of historical or current work activities involving asbestos-containing gaskets and packings such as the practice of removal. Most of the literature reports on the use of specific activities to determine compliance as opposed to exposures resulting from dry handling and worst case scenarios.

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Historically representative data is important in conducting exposure and dose reconstructions and in comparing historical exposures against those related to today's "good work practices."

Other investigators have attempted to measure worker exposure resulting from the handling or manipulation of asbestos-containing gaskets and packings. The U.S. Navy study by Liukonen et al.⁴¹ and two other studies published in journals were conducted in the field of workers under actual conditions. In the field study by Cheng et al.⁴² tests were performed while the gaskets were dry cut or removed under both wet and dry conditions. There are relatively few data points associated with the removal activities.

In the field study by Spence et al.⁴³ a comprehensive series of tests was performed while the gaskets were removed while being wetted, whereas traditionally these techniques are performed dry. The investigators utilized transmission electron microscopy (TEM) in accordance with National Institute for Occupational Safety and Health (NIOSH) method 7402⁴⁴ to distinguish asbestos fibers from interfering nonasbestos fibers. The investigators concluded the phase contrast microscopy (PCM) overestimated asbestos fiber concentrations in their study, even though the PCM results ranged from below detection to 0.02 fibers/mL.

One potential limitation of all the field studies was the assumption that the fibers counted by PCM⁴⁵ were all asbestos. Even if they were determined to be asbestos, an assumption would still need to be made that the counted fibers actually came from the respective gasket or packing being handled and not from some other asbestos fiber source.

It has been the authors' experience that in conducting field studies many variable conditions cannot be controlled; often conditions can only be recorded and reported. Simulated work environments may have the benefit of reducing the number of degrees of freedom by controlling or eliminating certain variables.

Three other published studies on gaskets and packings were performed in simulated work environments. In the simulated work environment study by Fowler⁴⁶ testing was performed while band-saw cutting gasket material. This was noted to be an unusual practice and therefore is of narrow or limited case-specific interest. In the simulated work environment study by McKinnery et al.⁴⁷ activities were performed in ways not representative of gasket activities observed in the workplace, and the analytical procedures were misused. The simulated work environment study by Millette et al.⁴⁸ focused only on the dry removal of packing and also misused the TEM procedure. A common problem with simulated work environment studies when definitively identifying asbestos fibers has been the use of direct or indirect preparation for TEM analysis utilizing "cleanliness" Asbestos Hazard Emergency Response Act of 1986 (AHERA)⁴⁹ or nonoccupational EPA,⁵⁰ International Organization for Standardization (ISO),^{51,52} or ASTM⁵³ analytical protocols rather than the prescribed direct preparation NIOSH TEM method 7402. When NIOSH method 7402 was used, it was incorrectly used as a counting technique rather than as a technique for determining the percentage of asbestos fibers present. The asbestos fiber concentration in air is to be calculated by multiplying the NIOSH 7400 PCM total fiber counts by the percentage of asbestos fibers determined in the NIOSH 7402 TEM analysis.

Additionally, in all the published studies the respective investigators either sampled specific short-duration tasks for comparison against a short-term exposure limit or projected, through calculation, a time-weighted average (TWA) for comparison against the permissible exposure limit (PEL)⁵⁴ or threshold limit value.⁵⁵

There are, therefore, limitations to both the field and simulated

work environment studies in determining fiber release for use in exposure assessments and historical dose reconstructions.

The purpose of this study was to carefully conduct a study of elastomeric asbestos-containing (fibrous) gaskets and impregnated asbestos-containing (fibrous) packing materials to determine the exposures that result from typical activities. For the study a testing protocol was developed for assessing personal exposure to fibers and general room air concentrations while conducting five different but commonly encountered activities. The five different activities evaluated included flat blade scraping, hand wire brushing, power wire brushing, making gaskets with a ball-peen hammer, and stem packing removal and replacement.

The objectives were to (1) utilize common techniques for handling gaskets and packings and facing flanges; (2) handle the gasket and packing materials in the way workers traditionally handled them; (3) perform tests at a rate typical of workers in the field; (4) conduct the testing without wetting the gasket or packing materials; (5) perform the tests in a controlled environment to eliminate interfering fibers and thus the need for fiber identification or confirmation by TEM; (6) utilize fittings from the field with a known history; (7) conduct the tests in accordance with good industrial hygiene practice; and (8) carefully document the variables associated with the testing and findings.

METHODS

Intact fittings were identified and removed from two different settings; industrial and maritime. The fittings and flanges selected had been in service many years and were obtained from a decommissioned power house or decommissioned U.S. Navy destroyers. Each fitting was rigorously cleaned prior to use in the study.

An isolation test chamber shown in Figure 1 was constructed in which to conduct the study. The chamber was 20 ft wide by 20 ft deep and 9 ft in height. It was constructed of two separate walls of 6 mil polyethylene sheeting to physically separate the activity being tested from outside-the-chamber influences. A work bench and hoist were placed in the center of the test chamber. The purpose of the chamber was to assure the elimination of fiber influences unrelated to the fitting gasket or packing.

The chamber was designed and constructed to be a static environment. During the test there was no air movement into or out of the chamber. This was verified by smoke tube examination from the outside and by carbon dioxide monitoring during the testing. Carbon dioxide concentrations usually started at 600 ppm at the beginning of the test cycle and peaked at 7000 to 8000 at the end of the test cycle. During the cleaning following each test cycle, the room was ventilated with high-efficiency particulate air (HEPA) filtered air being pushed into the chamber and air being drawn out of the chamber through another HEPA filter. Entry into the chamber was only through an access airlock. Between testing cycles the isolation chamber was ventilated, systematically wiped down, and determined to be clean by AHERA aggressive air sampling protocol.

The study was conducted as 10 separate cycles in an isolation chamber to eliminate outside influences. Each cycle was conducted at the rate of one fitting per hour over an 8-hour period. The frequency of one fitting per hour was based on the activity rates observed by the authors, reported in previous published field gasket studies, and those in reference estimating manuals,^{56,57} or reference text books.⁵⁸

Some 80 fittings with flanges ranging in size from 4–12 inches

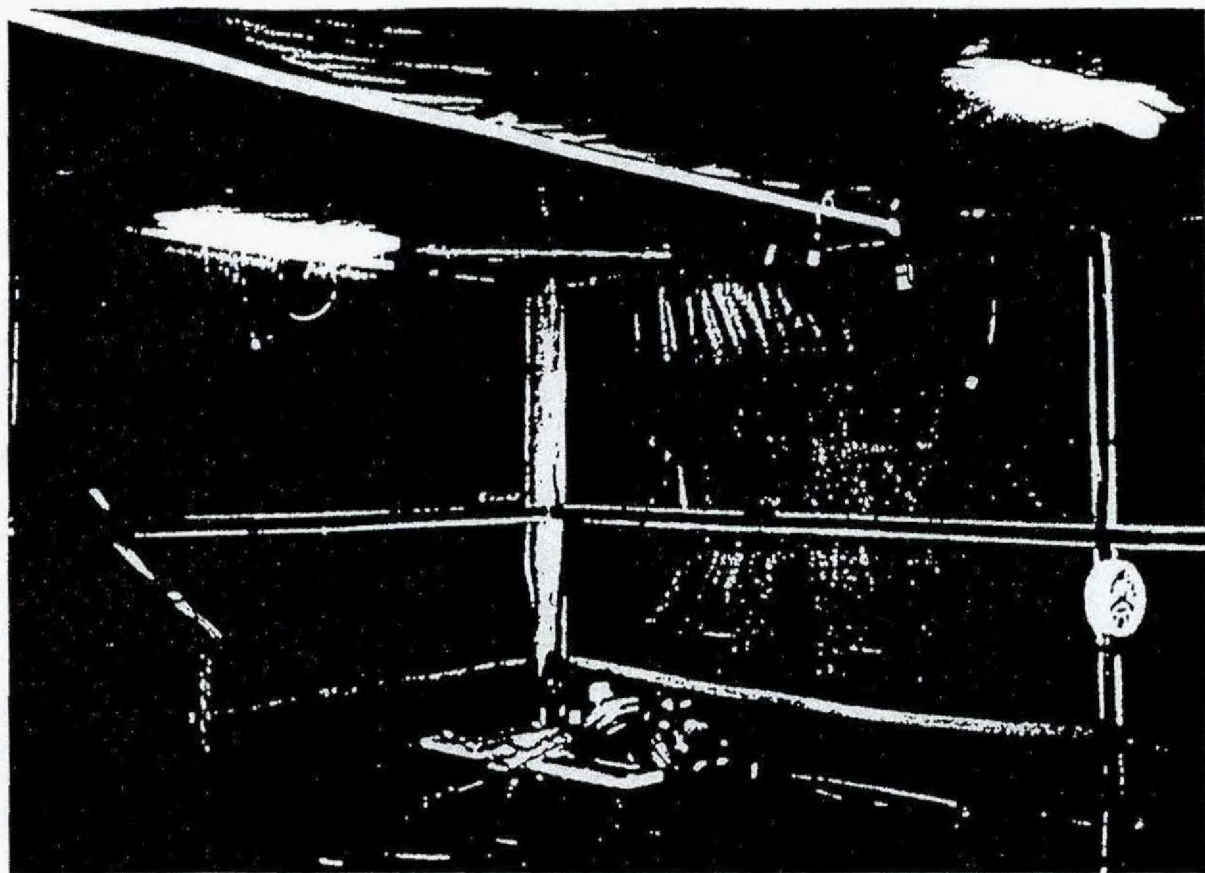


FIGURE 1. Isolation test chamber showing a fitting in place plus several samplers

in diameter and weighing from 2–200 pounds were used during the 10 testing cycles. During a particular testing cycle (i.e., power wire brushing an industrial fitting) a different fitting was handled each hour and its gasket removed and its flanges faced in a similar way. Eight fittings were thus used for each test cycle.

About 30 industrial fittings with a total of 50 flanges and 20 valve stems were assembled for the industrial phase of the testing. About 20 maritime fittings with a total of 40 flanges and 10 valve stems were assembled for the maritime phase of the testing. Physical information about the fittings was recorded. This included size of the flange, number of bolt holes, size of the bolt holes, and so forth.

All the fittings had intact gaskets as well as valve stems. In preparation for the testing the fittings were carefully blasted with glass beads to remove surface corrosion, rust, paint, insulation, and so forth. The gaskets and packings were left intact. Based on the careful room preparation plus systematic cleaning and handling of the fittings, there was a high degree of confidence that the only fibers in the test chamber would be a release by the respective gasket or packing activity being tested.

The first five test cycles conducted used "industrial fittings" from the decommissioned power plant. Test cycle 1 was "flat blade scraping," test cycle 2 was "hand wire brushing," test cycle 3 was "power wire brushing," test cycle 4 four was "making gaskets with a ball-peen hammer," and test cycle 5 was "stem packing removal and replacement." The next five cycles conducted used "maritime fittings" from the naval destroyers. Test cycle 6 was

"flat blade scraping," test cycle 7 was "hand wire brushing," test cycle 8 was "power wire brushing," test cycle 9 was "making gaskets with a ball-peen hammer," and test cycle 10 was "stem packing removal and replacement."

Each hour during the cycle, one of the eight fittings was positioned in the center of the room on the work bench ("cycle event"). The fittings selected for the particular test cycle were all placed in the isolation chamber before beginning the test cycle. A total of eight "cycle events" were conducted during the course of a test cycle which lasted 8 hours. A total of six test cycles composed of 48 cycle events were conducted during the gasket removal and flange "facing." The other four test cycles related to gasket making and packing removal activities.

The gasket removal and flange "facing" procedures used during each of the individual eight hourly "cycle events" were conducted in the same manner until the particular flange was "faced" and adequately prepared as if to receive a new gasket. The author and helper performed the procedures by trades such as pipefitters and mechanics following traditional techniques reported in the published literature and personally observed by the author. The gasket initially was removed with a flat blade scraper and the flange was faced with the respective finishing technique (flat blade scraper, hand wire brush, or power wire brush). All gasket and packing removal and replacement procedures were conducted dry. In Figure 2 an industrial fitting is shown being faced with a power wire brush.

Only fittings containing fibrous gaskets that appeared to be

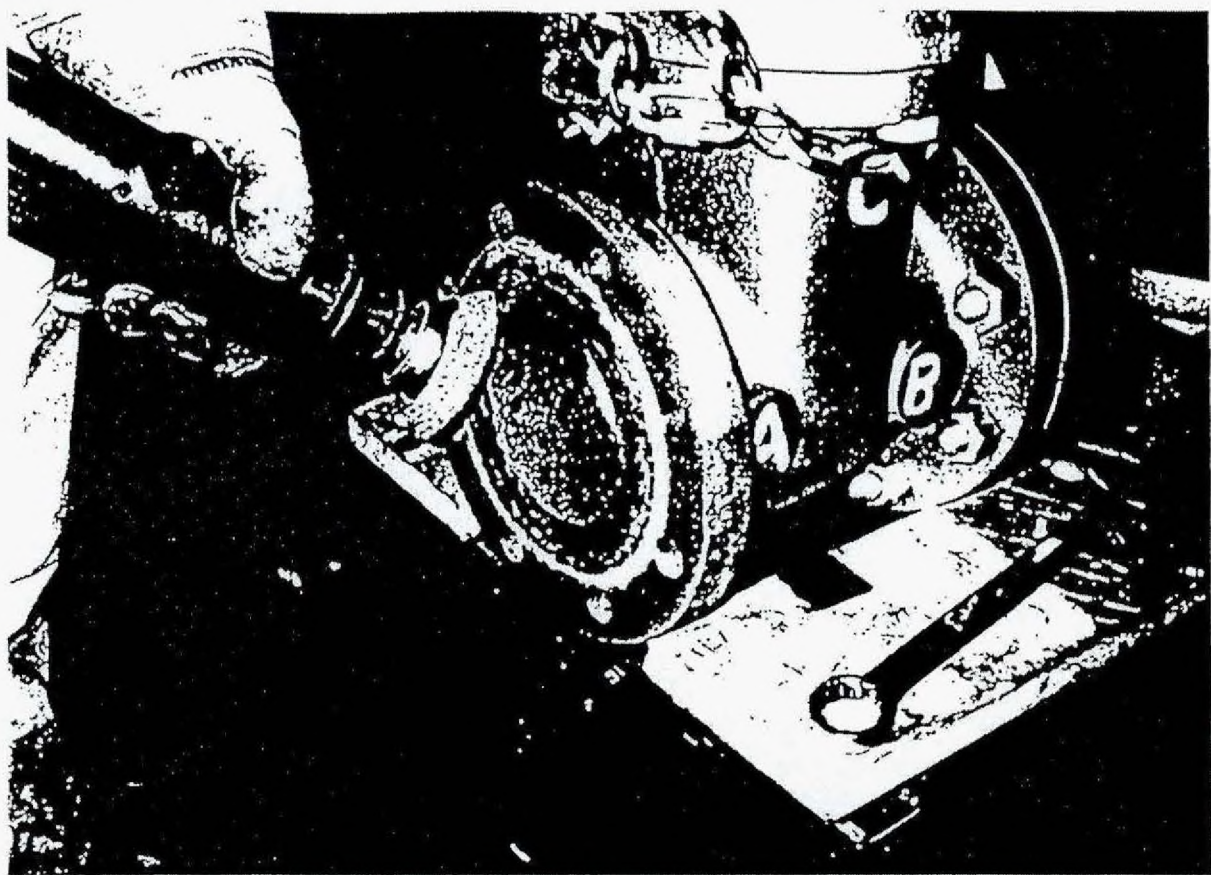


FIGURE 2. Flange of an industrial fitting being "faced" with a power wire brush

asbestos-containing and elastomeric (i.e., flexible) were used in the study. During each cycle event this was determined visually when the flange was actually opened, as shown in Figure 3. Gaskets that were not elastomeric (i.e., spiral wound metal) were rejected, and another fitting was selected for that event cycle. The necessity to reject a fitting occurred only three times in the course of the 48 event cycles when a gasket was being removed. All of the gasket and packing material removed was fibrous. All materials were retained and tested to verify asbestos content. When old gasket material was determined to contain asbestos, content ranged from 40 to 80% chrysotile. There were no crocidolite gaskets encountered.

The gasket-making sampling and event cycles were conducted identically to the methods used in the gasket removal and flange "facing" tests except that a new gasket was made. A fitting was selected that had been "faced" in a previous gasket removal test. New 1/16" thick Garlock 900 gasketing, which contains 60 to 80% chrysotile asbestos, was obtained and used for the event cycles. The 16 new gaskets were made using a ball-peen hammer, as shown in Figure 4.

The packing removal and replacement sampling and event cycles were conducted identically to the methods used in the gasket removal and flange "facing" tests except the valve stem packing was being removed and replaced. Removal and replacement of the stem packing for a particular fitting occurred during the same cycle (Garlock Sealing Technologies, Palmyra, N.Y.). A valve was selected and the old packing was removed (see Figure 5) and the

stems were repacked with new asbestos-containing packing material. The old packing material was all fibrous, and when it contained asbestos, it varied from 40 to 80% chrysotile. The "new" asbestos-containing packing material used for the event cycles was from unused new old stock (NOS). This material was Garlock style 733, which is a graphite impregnated 80% chrysotile square braided packing. The 16 valves were packed using new valve packing tools purchased from a catalog.

Personal samples were collected using OSHA monitoring methods in accordance with good industrial hygiene practice.²¹ Personal samples were collected from the breathing zones of the two individuals performing the work for the duration of the 8-hour test cycle. Samples were collected and analyzed by PCM following OSHA ID-160, which is essentially the same as NIOSH method 7400, A Rules.²² To eliminate variability, analysis was performed by the same analyst at the same laboratory accredited for PCM analysis by the American Industrial Hygiene Association. Personal air samplers were started at the beginning of the 8-hour test cycle and were stopped only during the lunch break.

To determine the general room air concentration, the isolation chamber was subdivided into 3600 modules of 1 ft³ each, and each module was assigned a discrete consecutive number for purposes of identification. For each cycle a random number generator was used to select 8 of the modules for sampling. A sample cassette was located in the center of the randomly selected module for the duration of the cycle, and samples were collected and analyzed



FIGURE 3. After opening the flange, the gasket was first verified as an elastomeric style.

following NIOSH method 7400, A Rules. General room air samplers were started at the beginning and were run during the entire 8-hour test cycle.

Prior to each test cycle the room was verified to be "clean" following "aggressive air" clearance monitoring protocols using a leaf blower and fans. The room cleanliness was verified as <70 s/mm² by collecting five air samples inside the chamber and analyzing them according to EPA AHERA, Appendix A, Post-Abatement Clearance TEM protocol.¹⁰ To eliminate variability, analysis was performed by the same analyst at the same laboratory accredited for TEM analysis by the National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP).

When possible prior to selecting a particular fitting for study, the presence of asbestos in the gaskets was verified; however, this was not possible to determine for every fitting. Because it was important to maintain the integrity of the gasket to flange face, a small pinch of gasket material was removed from the flange face gap without opening the flange. After the gasket removal cycle was completed, the removed gasket material was reserved, and a larger bulk sample was collected and analyzed. In addition to the old removed gasket material, bulk samples of the new gasket material used in the cycles in which a ball-peen hammer was used to make gaskets were collected and analyzed. Bulk samples were analyzed by polarized light microscopy (PLM) following EPA AHERA, Appendix E.¹¹ Analysis was performed by a laboratory accredited for PLM analysis by NIST under NVLAP.

Sampling results were formatted in a database for analysis. Statistical functions were performed including maximum, mean, minimum, and standard deviation. Additionally, collateral information was recorded in the database related to variable factors such as type of gasket, composition of the gasket, percentage of gasket adhering to a flange surface, gasket surface area, and minutes elapsed for removal.

RESULTS

A database of some 20 factors was developed to record variables related to each of the eight fittings used in the six gasket removal testing cycles. These factors included, for example, type of material (full-face gasket, ring gasket, partial-face gasket, or packing); composition of the gasket when asbestos-containing (40 to 80% chrysotile); percentage of gasket adhering to a flange surface (0 to 100%); condition of gasket (poor to excellent); gasket surface area (6 to 60 in²); and minutes elapsed for removal (1 to 24 min).

A database of some five factors was developed to record variables related to each of the eight valves used in the two packing removal testing cycles. These factors included, for example, shaft outside diameter (0.56 to 1.625 inches), packing housing outside diameter (1.25 to 2.625 inches), packing depth (0.31 to 1.875 inches), and minutes elapsed for removal (5 to 26 min).

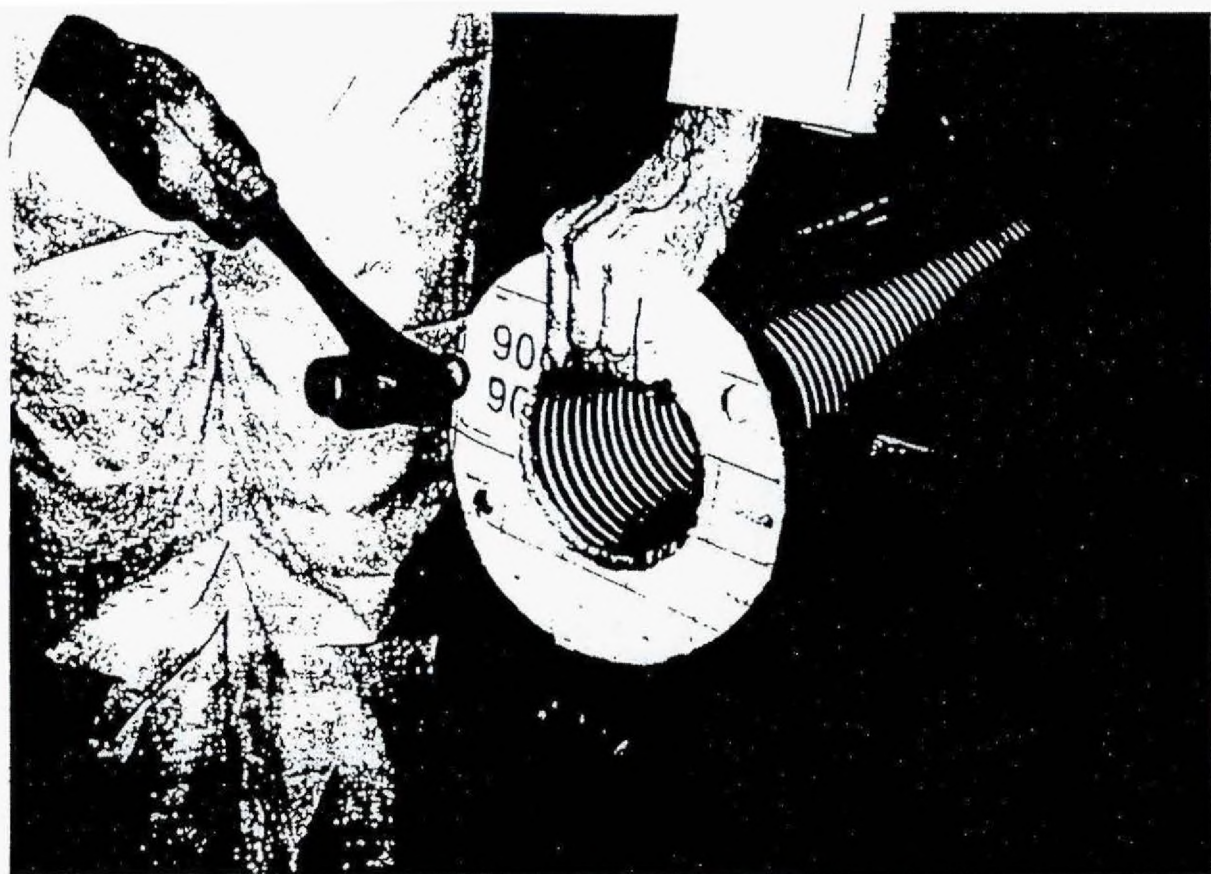


FIGURE 4. Punching bolt holes in a gasket made using a ball-peen hammer

Not surprisingly, a variety of gasket conditions were encountered, ranging from tightly adhered gaskets to loosely adhered gaskets. Of the 48 flanges, and therefore 96 flange faces, that were cleaned by either putty knife, hand wire brushing, or power wire brushing, only 1 flange face did not require any removal of residual gasket material. This happened to be related to a fitting during an industrial fitting putty knife test cycle. The other 95 flange faces had some material adhering to a flange face that required removal by the method being studied. Twenty-one flange faces were estimated to have 50% or more of the face covered with residual requiring removal.

Personal samples during the testing of "industrial fittings" ranged from 0.005 to 0.052 f/cc. The mean of the personal samples of the five "industrial" cycles was 0.026 f/cc. Standard deviations ranged from 0.001 to 0.008 f/cc. Table I shows the personal air sample results for the five test cycles in which industrial fittings were used.

Room air samples during the testing of industrial fittings ranged from 0.005 to 0.048 f/cc. The mean of the room air samples of the five industrial cycles was 0.023 f/cc. Standard deviations ranged from 0.001 to 0.006 f/cc. Table I shows the room air sample results for the five test cycles in which industrial fittings were used.

In test cycle 1, "industrial flat blade scraping," seven of the eight fittings used contained an asbestos gasket. The average of the personal samples was 0.031 f/cc, and the average of the area samples was 0.026 f/cc. In test cycle 2, "industrial hand wire

brushing," eight of the eight fittings used contained an asbestos gasket. The average of the personal samples was 0.006 f/cc, and the average of the area samples was 0.008 f/cc. In test cycle 3, "industrial power wire brushing," five of the eight fittings used contained an asbestos gasket. The average of the personal samples was 0.022 f/cc, and the average of the area samples was 0.017 f/cc. In test cycle 4, "industrial making gaskets with a ball peen hammer," eight of the eight fittings used had an asbestos gasket made. The average of the personal samples was 0.045 f/cc, and the average of the area samples was 0.040 f/cc. In test cycle 5, "industrial stem packing removal and replacement," eight of the eight valves used contained asbestos packing, and all were replaced with asbestos stem packing. The average of the personal samples was 0.026 f/cc, and the average of the area samples was 0.023 f/cc.

Personal samples during the testing of "maritime fittings" ranged from 0.000 to 0.029 f/cc. The mean of the personal samples of the five maritime cycles was 0.013 f/cc. Standard deviations ranged from 0.001 to 0.003 f/cc. Table I shows the personal air sample results for the five test cycles in which maritime fittings were used.

Room air samples during the testing of maritime fittings ranged from 0.001 to 0.025 f/cc. The mean of the room air samples of the five maritime cycles was 0.012 f/cc. Standard deviations ranged from 0.001 to 0.003 f/cc. Table I shows the room air sample results for the five test cycles in which maritime fittings were used.

In test cycle 6, "maritime flat blade scraping," eight of the

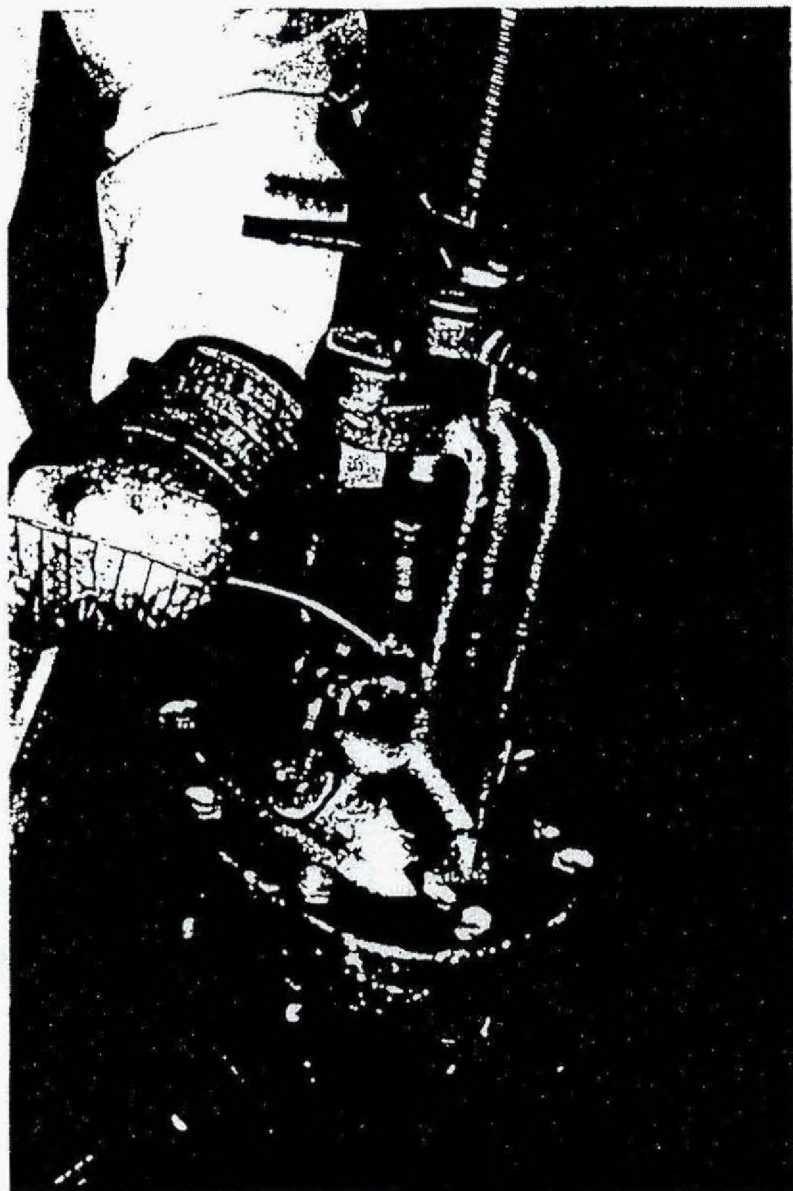


FIGURE 5. Digging out the stem packing after a hook did not work.

eight fittings used contained an asbestos gasket. The average of the personal samples was 0.017 f/cc, and the average of the area samples was 0.017 f/cc. In test cycle 7, "maritime hand wire brushing," four of the eight fittings used contained an asbestos gasket. The average of the personal samples was 0.002 f/cc, and the average of the area samples was 0.002 f/cc. In test cycle 8, "maritime power wire brushing," eight of the eight fittings used contained an asbestos gasket. The average of the personal samples was 0.009 f/cc, and the average of the area samples was 0.011 f/cc. In test cycle 9, "maritime making gaskets with a ball peen hammer," eight of the eight fittings used had an asbestos gasket made. The average of the personal samples was 0.026 f/cc, and the average of the area samples was 0.021 f/cc. In test cycle 10, "maritime stem packing removal and replacement," six of the eight valves used contained asbestos packing, and all were replaced

with asbestos stem packing. The average of the personal samples was 0.009 f/cc, and the average of the area samples was 0.008 f/cc.

In summary, all 48 gaskets removed were elastomeric and fibrous, and 40 of them were determined to be asbestos-containing. All 16 of the gaskets made using a ball-peen hammer were made from asbestos-containing sheet stock. All 16 packings that were removed were impregnated and fibrous, and 14 of them were determined to be asbestos-containing. All 16 of the packings that were replaced were from NOS asbestos-containing packing.

DISCUSSION

The air sampling results from both the five industrial test cycles and the five maritime test cycles were not significantly different

TABLE I. Ten Test Cycle Sampling Results

Test Cycle Description	Sample Type	Sampling Data Analysis			
		No. Samples	Maximum (f/cc)	Mean (f/cc)	Standard Deviation
Industrial #1—Flat blade scraping	personal	2	0.035		0.028
	room air	8	0.034	0.026	0.004
Industrial #2—Hand wire brushing	personal	2	0.007		0.005
	room air	8	0.010	0.008	0.002
Industrial #3—Power wire brushing	personal	2	0.023		0.021
	room air	8	0.020	0.017	0.001
Industrial #4—Making gaskets with a ball-peen hammer	personal	2	0.052		0.038
	room air	8	0.048	0.040	0.006
Industrial #5—Stem packing removal and replacement	personal	2	0.027		0.024
	room air	8	0.031	0.023	0.003
Maritime #6—Flat blade scraping	personal	2	0.019		0.014
	room air	8	0.020	0.017	0.002
Maritime #7—Hand wire brushing	personal	2	0.004		0.000
	room air	8	0.004	0.002	0.001
Maritime #8—Power wire brushing	personal	2	0.010		0.008
	room air	8	0.014	0.011	0.002
Maritime #9—Making gaskets with a ball-peen hammer	personal	2	0.029		0.022
	room air	8	0.025	0.021	0.003
Maritime #10—Stem packing removal and replacement	personal	2	0.010		0.008
	room air	8	0.011	0.008	0.002
Sample totals	personal	20			
	room air	80			

from each other. This was true for the personal samples as well as for the room air samples. Sample results for the 10 test cycles are shown in Table I.

The results of the 80 area samples and 20 personal samples indicate that no single sample ever exceeded the 8-hour TWA PEL of 0.1 f/cc and that only 1 personal sample (at 0.052 f/cc) ever exceeded half of this value. An upper confidence limit of all the personal samples was calculated to be 0.069 f/cc.¹² Therefore, based on these findings, it is unlikely that exposures would ever approach the PEL while these types of activities were performed, even when they were performed dry.

All samples were analyzed by direct preparation in accordance with NIOSH 7400. Because it was assumed all detected fibers were asbestos, it was not necessary to subsequently analyze these samples by TEM utilizing NIOSH 7402. Had definitive fiber identification been performed, it would have been incorrect to use a TEM method other than NIOSH 7402, because methodologies such as EPA's AHERA or Yamate protocol, as well as ISO, have no relationship with the epidemiologically derived fibers per cubic centimeter exposure standards based on the PCM. It would further be incorrect to compare the TEM unit of "structures/cubic centimeter" against the 0.1 f/cc allowable limits that are to be determined by PCM.

Intuitively, one would expect greater variation based on type of activity or asbestos content. For example, it would be reasonable to expect the airborne fiber concentrations to be greater for power wire brushing (industrial, 0.022 f/cc; maritime, 0.009 f/cc) than they would be for flat blade scraping (industrial, 0.031 f/cc; maritime, 0.017 f/cc). One would also expect that an activity that was literally identical between the industrial (0.045 f/cc) and maritime (0.026 f/cc) test cycles, namely that of making a gasket with a ball-peen hammer, would yield more similar numbers results because it was the same hammer, same sheet material, similarly clean flange faces, and same people doing the work in a cleanroom.

The numerical results would appear to show some differences.

But analysis of the database did not yield any significant correlation between the air sample results and the multitude of recorded variables, including whether the material contained asbestos. One reason was that few fibers were detected on the filters, so a variation of a few fibers counted made a significant difference in the reported value. Further, all fibers were being counted as asbestos whether they were or were not asbestos.

Also, the room air sample results were not significantly different from the personal air sample results for each of the test cycles. This was not surprising, because there was no ventilation in the room during testing, and over an 8-hour period it is reasonable to expect the personal samples would reflect the general air quality in a room with no ventilation.

The results of this carefully controlled study are consistent with other published studies in which the sampling and analytical methods are believed to have been properly followed for comparison against the OSHA 8-hour TWA allowable exposure. For example, the results for dry scraping and power sanding reported by Cheng et al. calculate as 0.03 and 0.07 f/cc on an 8-hour TWA, respectively. The results for production removal of hard-to-remove plate (sheet) gasketing reported by Spence et al. are shown to range between nondetection and 0.005 asbestos f/mL on an 8-hour TWA. Also, the results for installation and removal of sheet gaskets as reported by Liukonen et al. show averages ranging from 0.03 to 0.09 f/cc. All of these studies were conducted in actual workplace situations where there were other fiber influences.

CONCLUSIONS

This exposure assessment showed that the rate of fiber release for old and new elastomeric asbestos-containing gaskets and impregnated asbestos packing materials are insignificant even when the materials are manipulated dry. Although there is some quantified total fiber exposure during the activities typically performed by workers while using elastomeric asbestos-containing

gaskets and impregnated asbestos packing materials, all sample results showed the airborne concentrations of fibers to be well below the current OSHA PEL of 0.1 f/cc as sampled over an 8-hour TWA period. This is regardless of the activity being conducted and whether the activity was removal of an old elastomeric gasket or impregnated packing material or replacement with new elastomeric gasket or impregnated packing material.

The study methods controlled for potential interference that could impact analytical confidence at the very low fiber concentrations related to gasket and packing activities. The study methods also yield a high degree of confidence that the fiber concentrations reported are those resulting from the respective gasket or packing removal or replacement activity. Further, the results were obtained using tools and techniques as well as traditional worker methods with only dry materials, dry removal, and dry replacement techniques under conditions of no ventilation in a contained room. The results of this simulation, therefore, represent worst case conditions and are likely higher than those that would be experienced in actual working conditions out of doors or in ventilated spaces if interfering fiber sources could be eliminated from those settings.

These findings are useful for exposure assessments and dose reconstructions related to historical activities and to current activities in which dry methods are used.

ACKNOWLEDGMENTS

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