REVIEW AND ANALYSIS OF STUDIES THAT MONITORED FIBER EXPOSURES DURING MAINTENANCE OF ASBESTOS-CONTAINING RESILIENT FLOOR TILES

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INTRODUCTION

The Occupational Safety and Health Administration has proposed new rules to replace existing rules for control of occupational exposures to asbestos in general industry and in the construction industry (Fed. Reg. 55:29712-29753). One activity covered by the general industry rule is the maintenance of asbestos-containing resilient floor tiles. Given the difference between routine maintenance of a non-friable material and many of the activities covered by the general industry standard, some of the requirements of the standard may not be needed for the protection of workers whose only potential for exposure is in the maintenance of resilient floor tiles. To understand the necessity for applying various provisions in the standard to the case of resilient floor tile maintenance, it is necessary to understand what levels of exposure can be experienced by workers performing routine maintenance.

A variety of studies have been conducted on worker exposures to fibers during maintenance of asbestos-containing resilient floor tiles. Armstrong World Industries requested ENVIRON Corporation to review, summarize, and evaluate available studies. A discussion of selected studies follows.

SELECTED STUDIES

ENVIRON Study[1]

The Resilient Floor Covering Institute and Armstrong World Industries, Inc. have sponsored a study of worker exposure to fibers during spray buffing, scrubbing, and stripping vinyl asbestos or asphalt floor tiles following work practices recommended by the resilient floor covering industry. ENVIRON, with the assistance of Industrial Health Incorporated and the R.J. Lee Group, conducted personal and area sampling using the OSHA Reference Method for occupational exposures to asbestos, which is the approved method for determining

[1] ENVIRON Corporation. 1990. Evaluation of exposures to airborne fibers during maintenance of asbestos-containing resilient floor tiles using recommended work practices. Arlington, VA: ENVIRON Corporation. September 10.

compliance with the general industry and construction standards for asbestos. ENVIRON's fully documented report concludes that all worker exposures to fibers were well below the existing Action Level and proposed new Permissible Exposure Limit of 0.1 fibers per cubic centimeter (f/cc) by phase-contrast microscopy (PCM). Time-weighted average exposure levels were reported to average 0.025 f/cc for all types of maintenance combined. The study also found 30-minute exposures to fall below the Excursion Limit of 1.0 f/cc by a wide margin.

MacDonald Study[2]

Data from a study sponsored by the S.C. Johnson Wax Company have been reported by MacDonald and his colleagues. MacDonald sampled six maintenance operations including spray buffing, wet stripping with and without a sealer under the wax, and dry buffing with and without a sealer under the wax. The sixth operation entailed mopping on a sealer and wax onto the stripped floor. MacDonald states that the study used the TEM measurement technique specified by the regulations promulgated under the Asbestos Hazards Emergency Response Act (AHERA) and gives results in terms of structures per cubic centimeter (s/cc). When discussing the results, however, the authors make comparisons to the OSHA action level, which is expressed in terms of f/cc by PCM. Although not stated, MacDonald may have used OSHA counting rules and counted only fibers longer than 5 μm.

MacDonald reports no detectible asbestos fibers for wet stripping with a black pad or wet stripping with a green pad when a sealer was in place. For spray buffing, MacDonald reports a concentration of 0.062 s/cc, which would be entirely consistent with the ENVIRON results if the measurement technique was equivalent to the OSHA Reference Method. If MacDonald counted all fibers, the concentration of long fibers would be lower than 0.062 f/cc.

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[2] MacDonald, H.S., D.J. Grosse, V.M. Kushnaryov, and S. Kolinsky. 1990. Maintenance of vinyl asbestos tile floors: The effect of floor finishes on the release of asbestos from VAT floors. ECON: Environmental Contractor. July.

Dry buffing, as might be expected, produced more fibers: 0.95 s/cc with no sealer and 0.20 s/cc with a sealer. With the sealer, however, none of the fibers proved to be asbestos under TEM examination. MacDonald recommends against dry buffing a stripped floor, a recommendation consistent with the resilient floor covering industry's recommended work practices.

A.F. Meyer Study[3]

Under sponsorship by WRC-TV in Washington, DC, A.F. Meyer and Associates ("Meyer") conducted measurements of activities in a school in Montgomery County, Maryland. Maintenance procedures studied included spray buffing, stripping with a stripping solution and an aggressive pad, and stripping with an aggressive pad and only a mist of stripping solution. The tests were performed inside a containment built of plastic sheeting. One 8-hour personal sample was collected for analysis by PCM and was reported as showing 0.013 f/cc, which is within the range measured by the ENVIRON study. Although the Meyer text is not entirely clear on this point, it appears that the worker wore the sampling filter during all three type of activities. Most of the report's conclusions, however, focussed on results of area monitoring analyzed by transmission electron microscopy (TEM).

Although the authors of the Meyer report later expressed concern about its interpretation in the media, WRC-TV portrayed the study not as showing minimal exposures to maintenance workers but as demonstrating significant fiber releases potentially affecting school children after maintenance was complete. That interpretation and some of the statements in the report itself are flawed, for a variety of reasons. First, the study was not scientific in the sense of having a clearly articulated hypothesis that could have been tested by the data gathered. As reported, the Meyer study was also brief and limited in a number of significant ways, as the authors note in the introduction to the report. Other problems with the study are not so much in its implementation as in its interpretations, which have claimed more significance than justified.

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[3] A.F. Meyer and Associates, Inc. 1989. Untitled, undated report prepared for WRC-TV regarding sampling conducted on October 19, 1989, at the Sligo Middle School.

The Meyer study attempted to determine "whether or not there is a potential to release asbestos fibers from the tiles during buffing and stripping." The first two operations described appear from the limited description given to be reasonably representative of operations that could be conducted in maintaining resilient floor tiles, although a black pad is not recommended for stripping and is not consistent with the resilient floor covering industry's recommended work practices; the third is an exceedingly aggressive technique that might be deemed dry stripping and that is also not part of the resilient floor covering industry's recommended floor maintenance procedures.

The PCM method is generally suited to the determination of exposure to workers and is designed to detect both asbestos fibers and other structures of similar appearance that meet the counting rules (> 5 micrometers (μm) long and at least 3 times as long as wide). The action level for an 8-hr time weighted average exposure to workers is 0.1 fibers per cubic centimeter (f/cc) of air; the single sample taken was reported as 0.013 f/cc by PCM analysis, well below the action level and only slightly elevated over background samples taken outside the work area. Consequently, there is no reason to believe that worker exposure exceeds the proposed OSHA PEL during the operations conducted.

The TEM method was designed to count fibers that are longer than 0.5 μm and, depending on the purpose of the measurement, at least 3 times as long as wide or at least 5 times as long as wide. TEM also counts other structures ("bundles, clusters, and matrixes") that contain such fibers, but only structures that are confirmed to contain fibers of one of the several varieties of asbestos. For federal regulatory purposes, TEM is used only for assessing whether cleanup following response actions taken under the Asbestos Hazards Emergency Response Act (AHERA) is adequate. (AHERA uses only structures more than 5 times as long as they are wide. Why Meyer chose a 3-to-1 aspect ratio is unclear.)

The study as conducted is not an AHERA clearance determination. The operations conducted are not response actions, which are limited to removal, encapsulation, or enclosure. Even had the study been conducted following an AHERA response action, it would have failed to determine the adequacy of clearance. AHERA clearance sampling is intended to determine whether cleaning the area in which the response action was taken is sufficient to reduce asbestos concentrations inside the area to a level indistinguishable by a

statistical test, from concentrations outside the area. At least five samples inside the area must be analyzed to determine the presence of asbestos; if the average count of qualifying structures is less than 70 structures per square millimeter (s/sq mm) on the filter, the area can be considered clear. If it is greater, the area may still be considered clear if the inside samples show average structure concentrations not significantly different from the average of five outside samples. The Meyer study obtained only 2 samples inside the area after operations were completed (with no special attempts to clean the room), and only one outside; furthermore, no statistical analysis was presented to compare these three measurements, which were qualitatively similar. None of the samples taken during the maintenance operations would have been relevant to an AHERA clearance action.

Beyond these procedural objections, the study leaves many additional questions unanswered.

First, the bulk sampling of the resilient floor tile shows that it contains only chrysotile asbestos, as expected. Yet the data sheets provided by the R.J. Lee Group (which performed the TEM analyses) show that tremolite, actinolite, and amosite asbestos structures were also detected, which implies that other sources of asbestos were present in the area. This notion is strengthened by the finding that outside samples taken both before and after the operations studied, as well as samples taken inside the area before the operations began, also are reported as containing asbestos structures, both chrysotile and other types. Although some of these latter samples are below the nominal background level of 70 s/sq mm, they are above the usual level seen in samples from clean air.

Second, dust samples taken following the last stripping operation showed only a "trace" of chrysotile asbestos on the buffing pad. Yet the filters exposed during that operation showed "excessive loading" and needed to be analyzed by an indirect method that is not comparable to direct analyses and that ordinarily results in a larger count of fibers than would the direct method. The source of the material causing the overloading was not identified.

Third, the text of the report does not indicate what procedures were used for "aggressive sampling" following the maintenance operations. AHERA regulations specify

how aggressive sampling is to be accomplished, but the report does not explicitly state that this guidance was followed.

Fourth, nearly all the structures found by TEM were shorter than 5 μm. No more than 1 fiber greater than 5 μm was found in any of the samples analyzed, including the samples taken during the dry stripping operation and analyzed indirectly.

In summary, this study is virtually uninterpretable. The conclusion that fibers were released in quantities sufficient to trigger any regulatory response or to cause any significant health risk is not supported by the study.

Los Angeles Unified School District Study[4]

Stimulated by the television reports stemming from the Meyer study, the Los Angeles Unified School District (LAUSD) conducted a series of tests in a closed school, the Prairie Street School in Northridge, CA. Although the design was in some ways similar to that of the Meyer study, it is in many ways more careful and extensive, as well as being better documented.

Tests were made of stripping, scrubbing, and buffing operations. Both buffing of a freshly waxed floor and spray buffing to renew a floor were included. Several different grades of pad were used in the various procedures. Plastic enclosures were built inside each room tested. Personal sampling of worker exposure were taken during the maintenance procedures and analyzed by PCM. Consistent with ENVIRON, McDonald, and Meyer findings, worker exposures easily met OSHA standards (range, 0.002-0.009 f/cc).

Area samples were also taken for TEM analysis. Usually, 5 samples were taken in each location/situation. Samples were taken of air inside and outside the classroom before the maintenance procedure commenced, inside the classroom while the work was being done, and inside the classroom by aggressive techniques after the maintenance was completed. Only one average "background" measurement is reported (21 s/sq mm on the filter). While

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[4] Los Angeles Unified School District. 1990. Vinyl Asbestos Floor Tile Study. Prepared by the Business Services Division, Environmental Health and Safety Branch. Los Angeles, CA: Los Angeles Unified School District. March.

not entirely clear from the text, this value is probably the result of sampling inside the classroom prior to maintenance. Values reported in the room after aggressive sampling following the removal ranged from 9 to 355 s/sq mm on the filters. Values reported in the room *during* maintenance ranged from 20 to 8946 s/sq mm.

LAUSD interpreted these data to mean that scrubbing and stripping operations with blue, green, dark red, and black pads would "fail" a "clearance" test. The basis for that conclusion was that the USEPA AHERA clearance criterion was 70 s/sq mm. This conclusion is unwarranted on several grounds.

First, as noted in the comments on the Meyer study, maintenance is technically not a response action under AHERA and is therefore not subject to clearance standards. Response actions are intended to remove or isolate asbestos-contining materials. Clearance testing following response actions is intended to confirm whether the cleanup is adequate. The results of clearance sampling are not designed to assess airborne fiber concentrations to which building occupants are exposed.

Even if the clearance procedure applied to maintenance, several difficulties remain. Passing a clearance test implies that the air in the area where a response action has taken place is essentially no different from other air in the general vicinity. This test is only relevant after the activity is complete. LAUSD incorrectly applies the term "fail" to levels measured in the air *during* maintenence; these values are essentially irrelevant to the clearance determination. Therefore, LAUSD could not support its conclusion that scrubbing with a blue pad would fail clearance on the basis of a work-time measurement.

Furthermore, a comparison of samples inside and outside the room is intended under the AHERA provisions. Because the analytic sensitivity of TEM measurements is limited to 70 s/sq mm on the filters, a practical conclusion is that the room passes whenever the inside samples are found to be lower than 70 s/sq mm. The converse is not true: exceedance of 70 s/sq mm alone does not imply failure. To fail the test, the concentration of fibers in the *air* of the room (expressed in s/cc) must be statistically greater than the concentration in air outside the room as measured simultaneously with the inside samples. Statistical significance is determined by a procedure known as the "Z-test." LAUSD did not perform a Z-test, nor did it take simultaneous samples. Not enough information is provided to know whether the

samples that "failed" the 70 s/sq mm test would also fail the Z-test. For 5 samples each, the inside air *concentrations* need to be approximately 7 times larger than outside air concentrations for the test to fail.

LAUSD also analyzed samples of wastewater for asbestos fibers, and concluded they exceeded EPA standards. The standards in question are for drinking water or ambient water that could be used as a potable water supply, and would not apply to wastewater. Dilution of the small quantities of wastewater generated would easily meet the standard. In any case, the justification for the standard has recently been brought into question by EPA's withdrawal of a cancer slope factor for ingested asbestos.

Atlantic Environmental Study[5]

Atlantic Environmental, Inc. (AEI) reported on a study conducted at the Ironia School in Ironia, New Jersey. The AEI studies were conducted inside 4'x4'x7' portable plastic containments, which may have severely limited both air circulation and worker mobility, making the studies very unrepresentative of normal maintenance practices. AEI monitored fibers during wet stripping and "semidry" stripping. Additionally, AEI monitored an operation entailing stripping with a "non-scrubbable stripper mixture." Only area monitors were employed; no personal samples were taken. Generally, one sample each by PCM and TEM were taken for each of the three situations. The results by PCM showed results from less than the detection limit (0.002 f/cc) to 0.007 f/cc, which are remarkably low and demonstrate compliance with the current OSHA action level. The conclusions of the report again emphasized the results by TEM and voiced concern about fiber release.

The AEI work shared many of the limitations found in the A.F. Meyer study and also demonstrated little appreciation for the differences in interpretation of asbestos measurements by various techniques or their application to compliance with asbestos regulations. In summary, AEI studied conditions that cannot be related to real working conditions.

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[5] Atlantic Environmental Incorporated. 1989. Untitled report prepared for the Randolph Board of Education regarding a study conducted on May 30, 1989, at the Ironia School. Dover, NJ: Atlantic Environmental Incorporated June 14.

incorrectly applied different methods of asbestos monitoring to determinations of safety, used methods that are not standard for any regulatory purpose, and failed to explain discrepancies among the data reported.

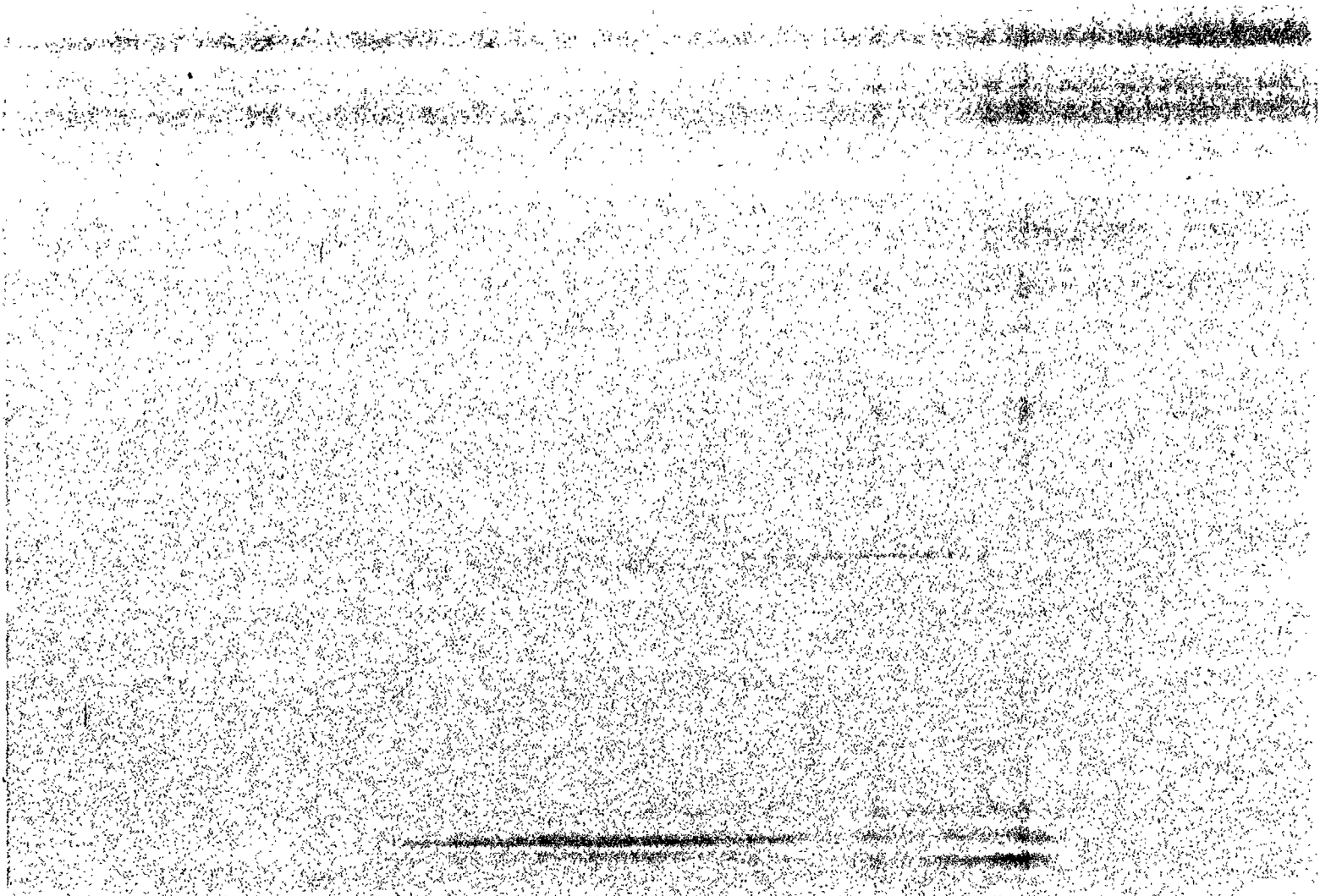
SUMMARY

When the studies reviewed above are examined carefully, they all are consistent with the finding that worker exposure levels during resilient floor tile maintenance activities are below the current action level and proposed PEL for airborne asbestos, if analyzed by the OSHA Reference Methods by PCM. (See Table 1.) Most of the seeming disagreements among the studies are based not on great differences in measured fiber levels but instead on the interpretations offered, particularly regarding the significance of clearance-type sampling analyzed by TEM. These disagreements are irrelevant to the setting of occupational standards to be monitored by PCM.

TABLE 1

Summary of Worker Exposures to Fibers During Maintenance of Resilient Floor Tiles

Author and Date	Operation	Exposure *(PCM f/cc)*	TWA?	Notes
MacDonald et al. 1990	Spray Buffing	0.06	No	Standard practice
		0.20	No	With Sealer
		0.95	No	No sealer or finish
		n.d.[a]	No	With sealer
		n.d.	No	No sealer
A. F. Meyer 1989	Spray Buffing Wet Stripping Dry Stripping	0.01	No	Cumulative over all three operations; Interpretations unwarranted
Los Angeles Unified School District 1990	Spray Buffing	< 0.01	Yes	"Passes clearance"
	Wet Scrubbing	< 0.01	Yes	"Fails clearance"
	Wet Stripping	< 0.01	Yes	"Fails clearance" Interpretations unwarranted
Atlantic Environmental 1989	Wet Stripping	n.d.	No	Area monitoring; Interpretations unwarranted
	Dry Stripping	< 0.01	No	
[a]n.d. = none detected				



EVALUATION OF WORKER EXPOSURE TO AIRBORNE FIBERS DURING THE REMOVAL OF RESILIENT FLOOR COVERINGS AND ASPHALTIC CUTBACK ADHESIVES USING RECOMMENDED WORK PRACTICES

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May 1, 1992

This report is an abridged compilation of four ENVIRON reports issued between April 3, 1989 and September 27, 1991. A copy of the full reports may be obtained from ENVIRON for a modest fee.

Summary

Many types of resilient floor tiles and sheet vinyl flooring manufactured in the past contained asbestos fibers bound in a vinyl or asphalt matrix.[1] Often, resilient floor tiles were installed with asphaltic cutback adhesives, some of which contained asbestos. Removal of both asbestos-containing resilient floor coverings and asbestos-containing cutback adhesives in an occupational setting (e.g., prior to installation of a new resilient floor covering) is subject to the standard set by the United States Occupational Safety and Health Administration (OSHA) for occupational exposure to asbestos in the construction industry (29 CFR 1926.58). This standard requires employers to assure that worker exposures to asbestos do not exceed the permissible exposure limit (PEL) of 0.2 fibers per cubic centimeter (f/cc) of air for an 8-hour time-weighted average (TWA) or the excursion limit of 1.0 f/cc averaged over a 30-minute period.[2]

The OSHA standard requires initial monitoring of employee exposure at the start of a job to establish that neither the airborne action level (0.1 f/cc for an 8-hour TWA), nor the excursion limit (1.0 f/cc over 30 minutes) is exceeded. The standard also provides that, in lieu of initial monitoring, an employer may rely upon objective or historical data, conducted under substantially similar workplace conditions, to demonstrate that the action level and excursion limit are not exceeded.

This report presents an analysis of fiber exposures to floor mechanics and observers during the removal of resilient floor coverings and cutback adhesives conducted pursuant to work practices recommended ("Recommended Work Practices") by the Resilient Floor Covering Institute (RFCI) and Armstrong World Industries, Inc. (Armstrong). Based on a total of 122 exposures measured for both floor mechanics and observers (representing typical exposures for supervisory personnel) in four separately conducted studies, the average TWA is approximately 0.022 f/cc, which is less than 25% of the action level. The 95% upper confidence limit for all removal operations is approximately 0.066 f/cc, which is less than 70% of the action level. Evaluation of samples by transmission electron microscopy (TEM) revealed that most of the regulated fibers counted were not asbestos. These studies also demonstrate, with 95% confidence, that the excursion limit would not be exceeded.

These studies constitute historical data that the action level and excursion limit will not be exceeded when resilient floor tiles, resilient sheet vinyl floor coverings, and asphaltic cutback adhesives are removed in accordance with the Recommended Work Practices.[3] The studies encompassed a variety of building types (residential, commercial, institutional), subflooring (wood, concrete, or hardboard), geographic areas, types of installation (perimeter- or fully-adhered), manufacturers, types and composition of products, age and condition of products

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[1] Asbestos has not been used in the domestic manufacture of resilient floor tiles, sheet vinyl flooring or asphaltic cutback adhesives since the mid-1980's.

[2] OSHA has proposed to lower the PEL to 0.1 f/cc (55 FR 29722, July 20, 1990).

[3] (1) Resilient Floor Covering Institute. July 1990. *Recommended Work Practices for the Removal of Resilient Floor Coverings.* (2) Armstrong. January 1992. *Recommended Work Practices for Removal of Resilient Floor Coverings.*

(including some damaged floors), relative difficulty of removal, and size and duration of removal. The circumstances covered by these studies span the full range of likely conditions for resilient floor covering and cutback adhesive removals. According to a recent communication from OSHA, the results of these studies "may be relied upon by employers in lieu of initial monitoring, provided the conditions prevailing in the employer's current operations (eg. type and composition of resilient floor cover materials, quantity of removal, work practices and duration of removal activity) closely resemble those on which the ENVIRON studies are based."[4] Consequently, an employer, in asserting a claim for exemption, may rely on the data collected in these studies, in lieu of conducting monitoring, to satisfy the initial monitoring requirements of the OSHA standard for any resilient flooring removal job performed in accordance with the Recommended Work Practices.

Introduction

Resilient floor tiles and sheet vinyl floor coverings are the preferred flooring material in many commercial and residential applications. In the past, the flooring or its backing utilized fibrous filler material, which included asbestos. The fibers were dispersed in a vinyl, asphalt, or rubber matrix that bound them into the material, thus minimizing the potential for their release during installation, use, and removal of the flooring.

Many resilient floors were installed with asbestos-containing asphaltic cutback adhesives. These adhesives were an oleo-resinous material with plastic/flexible properties. Typically, these adhesives contained approximately 5 to 20% asbestos fibers.

When new flooring is installed, removal of an existing resilient tile floor or sheet vinyl floor covering may be necessary. The Recommended Work Practices, however, advise that removal of resilient floor coverings, followed by the removal of any cutback adhesive, should be conducted only if new flooring cannot be installed directly on top of the existing floor. If the old flooring or adhesive contains asbestos, the floor mechanics who remove them are potentially exposed to airborne asbestos fibers during the removal process. Consequently, the removal process in an occupational setting is a workplace activity subject to OSHA regulations that limit employee exposures to airborne asbestos. As explained in the following section, OSHA has issued two standards regulating occupational exposures to asbestos, one for general industry (29 CFR 1910.1001) and one specifically for the construction industry (29 CFR 1926.58).

Any occupationally-related removal of an asbestos-containing material, such as resilient floor coverings or cutback adhesives, falls within the scope of construction work according to the OSHA definition. For this reason, the sponsors of these studies sought to obtain data to determine whether worker exposures to asbestos fibers during the removal of resilient floor coverings and cutback adhesives, in accordance with the Recommended Work Practices, are below the OSHA action level (0.1 f/cc as an 8-hour TWA) or the OSHA excursion limit (1.0

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[4] Letter from Patricia K. Clark, OSHA Directorate of Compliance Programs, to Walter D. Anderson, RFCI, and William B. King, Armstrong, dated January 16, 1992.

f/cc over a 30-minute period). These studies have been submitted to and reviewed by OSHA. The Agency has stated that these studies may be used as historical data, and an employer who follows the Recommended Work Practices may rely upon these data, in lieu of conducting initial monitoring of workers at future job sites.

A series of independent studies were undertaken by the resilient floor covering manufacturers to determine the potential worker exposure to fibers when resilient floor coverings and/or cutback adhesives are removed in accordance with the Recommended Work Practices. ENVIRON Corporation has analyzed the resulting data, which demonstrates that asbestos exposure during resilient floor covering and cutback adhesive removal performed in accordance with the Recommended Work Practices are lower, often substantially lower, than the OSHA action level of 0.1 f/cc. Moreover, analysis of the monitoring data show that the excursion limit of 1.0 f/cc also would not be exceeded. This report summarizes the measurements and the analyses that support these conclusions.

Regulatory Framework

In 1972, OSHA promulgated a Section 6(b) standard dealing with occupational exposures to asbestos for all industries covered by the Act (Occupational Safety and Health Act of 1970). On June 20, 1986 and September 14, 1988, OSHA issued revised standards relating to occupational exposures to asbestos for both general industry (29 CFR 1910.1001) and for the construction industry (29 CFR 1926.58). The 1972 standard had established a PEL of 2.0 f/cc as an 8-hour TWA. The present standards, among other things, reduced the PEL to 0.2 f/cc as an 8-hour TWA and set an excursion limit of 1.0 f/cc average over a 30-minute sampling period. OSHA has also set an action level of 0.1 f/cc calculated as an 8-hour TWA (29 CFR 1926.58(b)). Although the general industry standard is similar, further references will cite the construction standard only, because removal of resilient floor covering and cutback adhesives are classified as a construction activity according to OSHA.

The standard for the construction industry requires that each employer who has a workplace or work operation covered by the standard must, with certain exceptions described below, perform initial monitoring to determine the airborne concentrations of asbestos to which employees may be exposed (29 CFR 1926.58(f)(2)(i)). When the action level of 0.1 f/cc or the excursion limit of 1.0 f/cc is exceeded, the employer must continue to perform initial monitoring at the initiation of subsequent new asbestos jobs. Employee training and, under certain circumstances, medical surveillance are also required when exposures exceed the action level. When the PEL of 0.2 f/cc is exceeded, the employer must establish a demarcated, regulated area to which access is limited to authorized persons supplied with respirators (29 CFR 1226.58(e)). Certain additional conditions also apply to a regulated area. When the results of continued periodic monitoring reveal that employee exposures, by statistically reliable measurements, are below the action level and the excursion limit, initial monitoring of continued activities may be discontinued (29 CFR 1926.58(f)(4)).

OSHA provided two exceptions to the requirement for initial monitoring:

- where objective data demonstrate that employee exposures are below the action level and excursion limit (29 CFR 1926.58(f)(2)(ii)); or
- where the employer has historical monitoring data to rely upon in lieu of initial monitoring (29 CFR 1926.58(f)(2)(iii)).

The regulation states, in pertinent part (29 CFR 1926.58(f)(2)):

(2) Initial Monitoring:

(i) Each employer who has a workplace or work operation covered by this standard, except as provided for in paragraphs (f)(2)(ii) and (f)(2)(iii) of this section, shall perform initial monitoring at the initiation of each asbestos, tremolite, anthophyllite, or actinolite job to accurately determine the airborne concentrations of asbestos, tremolite, anthophyllite, or actinolite to which employees may be exposed.

(ii) The employer may demonstrate that employee exposures are below that action level and/or excursion limit by means of objective data demonstrating that the product or material containing asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals cannot release airborne fibers in concentrations exceeding the action level and/or excursion limit under those work conditions having the greatest potential for releasing asbestos, tremolite, anthophyllite, or actinolite.

(iii) Where the employer has monitored each asbestos, tremolite, anthophyllite, or actinolite job for the TWA, and where he has monitored after March 14, 1988, for the excursion limit, and the data were obtained during work operations conducted under workplace conditions closely resembling the processes, type of material, control methods, work practices, and environmental conditions used and prevailing in the employer's current operations, the employer may rely on such earlier monitoring results to satisfy the requirements of paragraph (f)(2)(i) of this section.

OSHA has determined that the ENVIRON studies, reviewed herein, evaluating exposure to airborne fibers during resilient floor covering and cutback adhesive removal, pursuant to the Recommended Work Practices, provide historical data that an employer may utilize in claiming an exemption from initial monitoring.[5]

[5] Letter from Patricia K. Clark, OSHA Directorate of Compliance Programs, to Walter D. Anderson, RFCI, and William B. King, Armstrong, dated January 16, 1992.

Recommended Work Practices for Removal of Floor Covering and Cutback Adhesives

RFCI and Armstrong have developed Recommended Work Practices for the removal of both resilient floor covering and cutback adhesive, regardless of whether these products contain asbestos. As explained below, the use of these work practices has been shown to comply with the exposure limits under the OSHA standards governing exposure to asbestos. These Recommended Work Practices, which have evolved from earlier recommendations, prohibit sanding or otherwise mechanically pulverizing the floor covering or any residual backing. Neither dry scraping of any residual backing material, nor dry sweeping of any removal-related material is recommended. Removal of an existing resilient floor covering, and the subsequent removal of any cutback adhesive, is recommended as an alternative only if new flooring cannot be installed on top of the existing resilient floor covering (for complete details on all of these removal activities, refer to the Recommended Work Practices[6]).

The Recommended Work Practice for removal of resilient floor tiles requires floor mechanics to remove individual tiles intact, to the extent possible, with a hand-held scraper. In the event that the tiles might not release with this method, a radiant heat source is recommended to loosen the tile from its binding adhesive. The heated tiles become quite pliable and can generally be removed with a long-handled scraper with a modest effort.

The Recommended Work Practice for removal of resilient sheet vinyl flooring requires two floor mechanics using a technique that features slicing the floor in 4- to 8-inch strips, peeling and rolling the wear layer while wetting the nip point between the wear layer and backing with a liquid detergent solution, and wet scraping of residual backing.

The Recommended Work Practice for removal of cutback adhesives requires floor mechanics to use either a wet scraping technique by hand or a wet mechanical removal technique that employs either a terrazzo floor machine or a low-speed floor machine fitted with a floor plate attachment, with a mixture of sand-blasting sand and water containing a liquid detergent solution. Alternatively, the adhesive can be loosened with a commercial wax stripping solution and removed using a floor buffing machine fitted with a black pad.

Additional work practices are recommended for use before and after removal. For example, the floor should be thoroughly vacuumed before and after removal with a High Efficiency Particulate Air (HEPA) vacuum cleaner. Removed floor covering and cutback adhesives are to be carefully placed in labeled, securely tied, impermeable trash bags and disposed of in an approved landfill. In addition, the HEPA vacuum bag should be removed according to the manufacturer's instructions and disposed of in labeled, securely tied, impermeable trash bags.

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[6] (1) Resilient Floor Covering Institute. July 1990. *Recommended Work Practices for the Removal of Resilient Floor Coverings.* (2) Armstrong. January 1992. *Recommended Work Practices for Removal of Resilient Floor Coverings.*

Monitoring Information

A comprehensive set of measurements of workplace exposures to airborne asbestos during resilient floor covering and cutback adhesive removal, pursuant to the Recommended Work Practices, was carried out by both Fowler Associates with the assistance of Chatfield Technical Consulting (Fowler-Chatfield) and by ENVIRON with the assistance of IHI and RJ Lee.[7] The analysis of the sampling data from the four studies conducted is presented in this report.

A number of different sampling sites were chosen for the various removal studies conducted. These sites encompassed a wide variety of building types (residential, commercial, and institutional), subflooring (wood, concrete, or hardboard), geographic areas, types of installation (perimeter- or fully-adhered), manufacturer, types and composition of products, age and condition of products (including some damaged floors), relative difficulty of removal, and size and duration of removal. These studies include a number of 8-hour workdays and longer, and encompass the full quantity of these materials that can be removed during a full work shift using the Recommended Work Practices. These removals are representative of a full range of likely removal conditions involving resilient floor covering and cutback adhesive removal.

Floor mechanics were locally obtained floor covering professionals, who were instructed prior to the commencement of any removal activities as to the Recommended Work Practices to be employed. Monitoring on the two workers, one observer (the Fowler-Chatfield study occasionally monitored two observers), and all stationary perimeter samplers began immediately before any floor removal activities commenced. All monitors were run continuously, except for personal monitors during lunch breaks at some sites, until the floor covering, cutback adhesive or both, depending on the parameters of the study, were fully removed and clean up was completed.

For all personal monitors, two companion samples were generally collected. In the "full-shift" study,[8] one set of personal monitors on each individual was run continuously throughout the day, except for lunch breaks. The second set of personal monitors was changed throughout the course of the day to obtain "partial-shift" samples for the floor tile and cutback adhesive phases of removal activity. Monitoring was not performed for subsequent activities following

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[7] Fowler-Chatfield conducted a resilient floor tile removal study on behalf of the sponsors, the data from which was analyzed by ENVIRON in a 1989 report (ENVIRON Corporation. April 3, 1989. *Evaluation of Exposure to Airborne Fibers during Removal of Resilient Floor Tiles Using Recommended Work Practices.*). ENVIRON, with assistance from IHI and RJ Lee, conducted three additional studies: an asphaltic cutback adhesive removal study in 1989 (ENVIRON Corporation. March 30, 1990. *Evaluation of Worker Exposure to Airborne Fibers during the Removal of Asphaltic Cutback Adhesive Using Recommended Work Practices.*); a resilient sheet vinyl floor removal study in 1989 (ENVIRON Corporation. March 30, 1990. *Evaluation of Worker Exposure to Airborne Fibers during the Removal of Resilient Sheet Vinyl Floor Covering Using Recommended Work Practices.*); and a "full-shift" resilient floor tile and cutback adhesive removal study in 1991 (ENVIRON Corporation. September 27, 1991. *Evaluation of Worker Exposure to Airborne Fibers during the Removal of Floor Tile and Cutback Adhesive Using Recommended Work Practices.*).

[8] ENVIRON Corporation. 1991. *Evaluation of Worker Exposure to Airborne Fibers During the Removal of Floor Tile and Cutback Adhesive Using Recommended Work Practices.*

removal of the resilient floor covering or cutback adhesive, such as the use of leveling compounds, installation of a new underlayment or installation of a new resilient floor covering, because asbestos-containing products were not being employed. In many instances, these post-removal activities will occupy as much as or more of the working day than the resilient floor covering and cutback adhesive removal and will not entail exposures to asbestos fibers.

In the studies overseen by ENVIRON, all air samples intended for Phase Contrast Microscopy (PCM) analysis were collected in accordance with NIOSH Method 7400 as recommended by OSHA. Samples were collected on Millipore 25 mm diameter, 0.8 μm pore size, cellulose ester membrane filters in cassettes with conductive cowls. Samples intended for Transmission Electron Microscopy (TEM) analysis were collected in accordance with EPA's Interim Transmission Electron Microscopy Analysis Method. Samples were collected on either Nuclepore or Millipore 25 mm diameter, 0.45 μm pore size, mixed cellulose ester fiber filters with 0.8 μm backup filters in cassettes with conductive cowls.

Personal monitoring of the floor mechanics and observers was accomplished in the breathing zone at a nominal pump flow rate of approximately 2.0 liters per minute. All samples were collected using cassettes in the open-face configuration. One sample filter was generally analyzed by PCM, the other by TEM. In the "full-shift" study, a protocol was developed wherein a single filter cartridge could be analyzed by both PCM and TEM.

For PCM analysis, one hundred fields were counted at a magnification of 400X following the rules outlined in NIOSH Method 7400. The method requires that 100 fields be counted, or at least a minimum of 20 fields, depending upon fiber concentration. All fibers or fiberlike particles measuring at least 5 μm in length and having a 3-to-1 length-to-width aspect ratio were counted. For TEM analysis, samples were analyzed using proposed EPA Level II analysis. The analysis for asbestos fibers consisted of fiber morphology, visual selected area electron diffraction (SAED), and elemental chemical analysis by energy dispersive spectroscopy (EDS), supplemented by the measurement and interpretation of micrographs of several SAED patterns. The samples were analyzed at a magnification of 20000X. Particles longer than 5 μm meeting the definition of a fiber length-to-width aspect ratio of greater than 3-to-1 and having substantially parallel sides were classified as chrysotile or amphibole following definitions developed by Yamate[9]. Structures containing such asbestos fibers are classified in conformance with the definitions in the EPA Interim Method.

PCM is the required procedure for monitoring employee exposure to airborne asbestos under OSHA regulations. PCM counts both asbestos and non-asbestos fibers meeting the counting rules. OSHA specifies PCM analysis primarily for practical reasons of cost and reliability, but also because the epidemiologic studies on which its standards are based used PCM or other optical microscopy to describe the exposure levels of the occupational cohorts studied. For any industry in which asbestos fibers are predominant among all particles meeting the counting rules (i.e., greater than 5 μm in length, greater than 0.25 μm in diameter, and having a length-to-width aspect ratio of at least 3-to-1), utilizing PCM is likely to yield appropriate conclusions regarding the level of asbestos exposures. If, on the other hand, the majority of

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[9] Yamate, G., S.C. Agarwal, and R.D. Gibbons. Methodology for the Measurement of Airborne Asbestos Fibers by Electron Microscopy. EPA Contract No. 68-02-3266.

observed particles are non-asbestos, then PCM analysis can exaggerate the potential worker exposure.

TEM was used in these studies, in part, to determine the proportion of true asbestos fibers among all fibers meeting the OSHA counting rules. As demonstrated in the studies conducted, only a small fraction of the particles observed under TEM analysis that strictly conformed to the PCM counting rules were actually asbestos fibers. The comparison of PCM with TEM counts is presented to demonstrate that PCM counts are probably overestimates of the true worker exposure to regulated asbestos fibers. Only the PCM results for personal monitoring are offer as historical data showing compliance with OSHA standards.

The importance of following the Recommended Work Practices during resilient floor covering or cutback adhesive removal is highlighted by the air quality characteristics typical of most indoor environments. Most residential, commercial, and institutional buildings can contain significant quantities of non-asbestos fibers that could be counted as asbestos under OSHA-required procedures. Fibers from textiles, mineral wool, fiberglass, and paper, in addition to asbestos, may be present in the floor removal environment, even after vacuuming. Many of these fibers could be falsely identified as asbestos fibers under the requirements to count all geometrically qualifying structures during PCM analysis, independent of their chemical or mineralogical classifications, thereby yielding potentially inaccurate or misleading results.

Analysis of Exposure Measurements

Fibers of asbestos and many other natural and man-made materials are found in virtually every type of environment, including structures where resilient floor coverings and cutback adhesives might be removed. Many of these fibers would qualify for inclusion under the geometric counting rules of the OSHA standard, independent of their composition or origin. These fibers are not attributable to floor removal activities and should not be counted against compliance with the action level. Therefore, acquisition of background concentration data on qualifying fibers is necessary in interpreting the exposure results attributable to floor and adhesive removal operations.

Some of the filters used in the personal monitors are made of materials that can be contaminated with asbestos fibers as well as other fibrous material. Such contamination should also not be attributable to floor removal activities and should not be counted against the action level. Therefore, blank filters, which were not exposed to the work environment, were analyzed for fiber counts. In all cases, no contamination of the filters was observed. Thus, the net PCM concentration is obtained by subtracting the background (outdoor) concentration. However, in order to obtain the most conservative estimate of potential worker exposure to airborne fibers, ENVIRON chose not to subtract measured background levels when calculating the net PCM concentration for each sample.

A further adjustment was also necessary to account for the fact that some of the floor and adhesive removal activities did not extend over a full 8-hour workday. Floor mechanics typically proceed to install new flooring following removal, or return to their home shop. These activities do not involve occupational exposure to asbestos. Consequently, the TWA concentrations are

lower than the adjusted measured concentrations by a factor of T/480, where T is the actual sampling time, in minutes, and 480 is the number of minutes in an 8-hour day.

A comparison of PCM analytical results with TEM analytical results must recognize that the counting methods employed are different. PCM analysis counts all fibers observed with no differentiation between asbestos and non-asbestos. Further, only fibers in excess of 5 μm in length and 0.25 μm in width, and with a 3-to-1 aspect ratio are counted in PCM analysis. The TEM count includes only asbestos fibers, but detects and counts all asbestos fibers that are greater than approximately 0.5 μm in length. TEM can also detect fibers less than 0.25 μm in width, which is the approximate limit of visibility for PCM. Because these studies were intended to examine exposures in terms of the OSHA standards, all asbestos fibers greater than 5 μm in length and with an aspect ratio of at least 3-to-1, regardless of width, were considered in the analysis of TEM data.

- The Fowler-Chatfield Study of Resilient Floor Tile Removal

The Fowler-Chatfield studies[10] followed then-current Recommended Work Practices, which deviated from the current Recommended Work Practices in that a HEPA vacuum was not used for cleanup. Therefore, the monitors undoubtedly captured preexisting fibers from the cracks between the tiles, as well as dust emitted from the ordinary shop vacuum that would not have been captured if the most recent Recommended Work Practices had been in effect. The magnitude of the influence of this difference on the fiber counts is difficult to estimate, but it is certain that the Fowler-Chatfield data represent exposures greater than those expected if a HEPA vacuum had been used, as is now recommended.

A total of 37 TWA measurements of floor mechanic and observer exposures were taken for analysis. The average TWA for both mechanics and observers is 0.022 f/cc. The 95% upper confidence limit is approximately 0.082 f/cc, which is below the 0.1 f/cc action level.

All of the adjusted TWA concentrations in this study were below the action level of 0.1 f/cc, except for one floor mechanic's value of 0.1867 f/cc. This value is suspect because it is grossly higher than the samples for workers and observers at this and other sites, and because no asbestos fibers were identified in the companion TEM analysis. It may be due, for example, to a puff of dust from the non-HEPA vacuum cleaner. Nevertheless, it is included in the statistical analysis to assure a worst-case analysis.

Fowler-Chatfield conducted their study before monitoring for the OSHA excursion limit was proposed. Therefore, no short-term (30-minute) measurements were made. A maximum 30-minute concentration was estimated by multiplying the net concentration by the sampling duration, in minutes, and dividing by 30 minutes. It should be noted that this calculation yields a theoretical maximum for any 30 minute period and significantly overestimates the actual excursion concentration.

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[10] ENVIRON Corporation. April 3, 1989. *Evaluation of Exposure to Airborne Fibers during Removal of Resilient Floor Tiles Using Recommended Work Practices.*

Since the estimated 30-minute concentrations are maximum values, no elaborate statistical analysis is warranted. All but one of the 41 values produced a concentration below 1.0 f/cc, averaged over 30-minutes. The one excursion limit outlier (2.988 f/cc) was the same one that appears to be an outlier in the statistical analysis for the TWAs and for which no asbestos was found in the companion sample by TEM analysis. Therefore, these results confirm the finding of OSHA that "there appears to be virtually no possibility that the excursion limit would be exceeded if the recommendations of the Resilient Floor Covering Institute were followed." (53 FR 35614, September 14, 1988).

- The ENVIRON Study of Asphaltic Cutback Adhesive Removal

The first ENVIRON study,[11] conducted in 1989, investigated the removal of asphalt cutback adhesives, pursuant to the Recommended Work Practices. A total of three removal activities, involving a total of seven exposure measurements of floor mechanics and observers were taken and analyzed in this study. On account of the low concentrations of airborne fibers observed, additional cutback adhesive removal studies were not conducted.

Without exception, all of the TWA concentrations were well below the action level of 0.1 f/cc. The average TWA for the seven samples analyzed is 0.0044 f/cc, which is less than 5% of the action level. The 95% upper confidence limit for cutback adhesive removal is 0.0066 f/cc, which is still less than 7% of the action level. Moreover, the results show that no regulated asbestos fibers were observed via TEM analysis for floor mechanic or observer samples. Thus, it can be reasonably concluded that the PCM results and, therefore, the TWA values for most samples, overestimate the actual number of asbestos fibers present.

The average TWA values were calculated from the net concentration by assuming that a floor mechanic would not conduct floor removal activities over a full 8-hour workday, every day. Even if it is conservatively assumed that a floor mechanic does perform floor removal activities for 8-hours every day, then the exposure level would be based upon the net concentration, rather than the 8-hour TWA. Under this assumption, the average exposure for these samples is approximately 0.010 f/cc, which is still 10% of the action level. It should be reiterated that these reported concentrations do not differentiate between asbestos and non-asbestos fibers.

As in the Fowler-Chatfield study, no samples were specifically taken to examine short-term exposures. A maximum 30-minute concentration was estimated by multiplying the net concentration by the sampling duration, in minutes, and dividing by 30 minutes. Again, it should be noted that this calculation yields a theoretical maximum for any 30 minute period and significantly overestimates the actual excursion concentration.

Since the estimated 30-minute concentrations are again maximum values, no elaborate statistical analysis is warranted. All seven values produced concentrations which were substantially below 1.0 f/cc, averaged over 30-minutes. In fact, the highest value is only about

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[11] ENVIRON Corporation. March 30, 1990. *Evaluation of Worker Exposure to Airborne Fibers during the Removal of Asphaltic Cutback Adhesive Using Recommended Work Practices.*

10% of the excursion limit value. These results similarly confirm the finding of OSHA that "there appears to be virtually no possibility that the excursion limit would be exceeded if the recommendations of the Resilient Floor Covering Institute were followed." (53 FR 35614, September 14, 1988).

- The ENVIRON Study of Resilient Sheet Vinyl Floor Covering Removal

The second ENVIRON study,[12] also conducted in 1989, investigated the removal of resilient sheet vinyl flooring, pursuant to the Recommended Work Practices. For the 17 floor removal locations in this study, a total of 51 exposure samples of floor mechanics and observers were taken and analyzed by PCM.

Without exception, all of the TWA concentrations are below the action level of 0.1 f/cc. The average TWA for these samples is approximately 0.027 f/cc, which is less than 30% of the action level. The 95% upper confidence limit for all resilient sheet vinyl floor removal operations is approximately 0.067 f/cc, which is less than 70% of the action level.

The average TWA values, as described earlier, were calculated from the net concentration by assuming that a floor mechanic would not conduct floor removal activities over a full 8-hour workday, every day. Even if it is conservatively assumed that a floor mechanic does perform floor removal activities for 8-hours every day, then the exposure level would be based upon the net concentration, rather than the TWA. Under this assumption, the average exposure for these samples is approximately 0.048 f/cc, which is still less than 50% of the action level. It should be reiterated that these reported concentrations do not differentiate between asbestos and non-asbestos fibers. TEM analysis clearly indicates that the number of asbestos fibers is a fraction of the total regulated fibers observed, such that the actual mean value may be significantly lower than 0.048 f/cc.

As in the Fowler-Chatfield study, no samples were specifically taken to examine short-term exposures. A maximum 30-minute concentration was estimated by multiplying the net concentration by the sampling duration, in minutes, and dividing by 30 minutes. Again, it should be noted that this calculation yields a theoretical maximum for any 30 minute period and significantly overestimates the actual excursion concentration.

Given that the estimated 30-minute concentrations are maximum values, no elaborate statistical analysis is warranted. The average of the excursion concentrations for floor mechanics and observers is approximately 0.426 f/cc, which is less than 50% of the excursion limit of 1.0 f/cc averaged over a 30-minute period. For a set of samples at one removal location, the calculated excursion concentrations exceeded 1.0 f/cc by a small margin. As these samples were collected over a 6.5 hour monitoring period, it is extremely unlikely that the actual excursion limit was exceeded during any 30-minute period. Nevertheless, 95% of these calculated maximum excursion values are below the 1.0 f/cc excursion limit. Since it is highly unlikely

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[12] ENVIRON Corporation. March 30, 1990. *Evaluation of Worker Exposure to Airborne Fibers during the Removal of Resilient Sheet Vinyl Floor Covering Using Recommended Work Practices.*

that the entire daily exposures observed in these studies occurred within any 30 minute period, the true excursion concentrations should be well below the values calculated.

At the onset of the resilient sheet vinyl floor removal study, the Recommended Work Practices called for the complete removal of an existing resilient sheet vinyl floor covering. The removals conducted at 16 of the floor removal sites closely followed these Recommended Work Practices. During the course of the study, an alternative Recommended Work Practice was established to allow the simultaneous removal of both the resilient sheet vinyl floor and its wood underlayment. According to this Recommended Work Practice, floor mechanics would follow the resilient sheet vinyl floor removal guidelines only to expose the joints in the suspended wood underlayment beneath the resilient sheet vinyl floor. After the removal of strips on either side of each joint, the underlayment is removed with the majority of the resilient sheet vinyl floor still attached. One floor removal followed this alternative Recommended Work Practice. The exposure results for this underlayment removal site were included in the overall statistical analysis. The PCM, TEM, and TWA concentrations for this study are well below the OSHA action level and excursion limit and, thus, are consistent with the exposure measurements at the other 16 sites.

- The ENVIRON Study of "Full-Shift" Resilient Floor Tile and Cutback Adhesive Removal

The third ENVIRON study,[13] conducted in 1991, investigated the removal of floor tiles and cutback adhesives over the course of a "full-shift" 8-hour workday, pursuant to the Recommended Work Practices. Removal activities at nine sites were monitored, resulting in 27 full-shift exposure samples of floor mechanics and observers.

Without exception, all of the "full-shift" TWA concentrations are well below the action level of 0.1 f/cc. The average TWA for these samples is 0.016 f/cc, which is 16% of the action level. The 95% upper bound confidence limit for all full-shift removal operations is approximately 0.033 f/cc, which is 33% of the action level.

As a second estimate of the exposures to floor mechanics and an observer at each removal site, the summation of the calculated TWAs for each partial-shift and excursion limit were compiled (i.e., the calculated TWA values for each individual monitoring activity comprising the full-shift removal were summed for each floor mechanic and observer to obtain a summation TWA).[14] The average summation TWA for these partial-shift and excursion limit samples is 0.025 f/cc, which is less than 26% of the action level. The 95% upper bound confidence limit for the summation TWA is approximately 0.063 f/cc, which is still well below the action level.

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[13] ENVIRON Corporation. September 27, 1991. *Evaluation of Worker Exposure to Airborne Fibers during the Removal of Floor Tile and Cutback Adhesive Using Recommended Work Practices.*

[14] The partial-shift monitoring separately covered: (1) removal of the resilient floor tile and (2) removal of cutback adhesives.

No TWA, either full-shift, partial-shift or excursion limit, was observed to exceed the action level.

During the course of the full-shift removal activity, an excursion limit sample was taken for either the floor tile or adhesive removal phase. The excursion limit samples taken at each site were approximately 30 minutes, in accordance with the OSHA standard, except at one site, where the shortest monitoring period was 60 minutes. The 60-minute samples were not included as part of the excursion limit analysis, but were treated, instead, as separate partial-shift samples. The average excursion limit concentration for mechanics and observers was 0.0518 f/cc.[15] The 95% upper bound confidence limit was 0.1943, which is less than 20% of the OSHA standard.

Conclusions

As demonstrated in the Fowler-Chatfield and ENVIRON studies, the removal of resilient floor coverings and asphaltic cutback adhesives, when carried out in accordance with the floor industry's Recommended Work Practices, results in airborne fiber levels considerably below the OSHA action level of 0.1 f/cc for asbestos fibers based on an 8-hour TWA and the excursion limit of 1.0 f/cc. According to the OSHA asbestos standard for the construction industry, initial monitoring would not be required for resilient floor covering or cutback adhesive removal jobs using the Recommended Work Practices, if historical data are available that establish that neither the action level of 0.1 f/cc (8-hour TWA) nor the excursion limit of 1.0 f/cc for a 30-minute average is expected to be exceeded.

Analysis of the airborne fiber concentration monitoring data collected for these studies clearly meets the OSHA requirements for historical data. The upper bound 95% confidence limit on the individual measurements of exposure to floor mechanics and observers conducted on 122 separate occasions is approximately 0.066 f/cc, which is less than 70% of the action level. In addition, it is highly unlikely that any floor mechanic would be exposed near the calculated upper bound 95% confidence limit every working day; therefore, the mean exposure level of approximately 0.022 f/cc is a better representation of the worker exposure. A breakdown of the personal monitoring results for the four studies discussed in this report are provided in Table 1.

Although samples were not specifically taken in each study to determine whether the excursion limit of 1.0 f/cc would be exceeded, a maximum 30-minute concentration was estimated by multiplying the net concentration by the sampling duration, in minutes, and dividing by 30 minutes. This calculation yields a theoretical maximum for any 30-minute period and

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[15] One worker's excursion limit exposure concentration was determined to be 0.3593 f/cc, which was more than 250% greater than any other sample analyzed. However, this particular worker had partial-shift sample concentrations significantly higher than his coworker and the observer, despite performing similar activities. Although the reason for this obvious inconsistency is not known, the sample was included in the analysis as if it were accurate. This inclusion does not affect the conclusion that neither the action level nor the excursion limit are exceeded. In fact, due to the apparent high values for this particular mechanic, both the full-shift and partial-shift filters were analyzed by TEM. None of the fibers observed via TEM, however, were regulated asbestos fibers under the PCM counting rules.

significantly overestimates the actual excursion concentration. In each case, the results of this analysis confirmed OSHA's finding that "there appears to be virtually no possibility that the excursion limit would be exceeded" if the Recommended Work Practices are followed (53 FR 35614, September 14, 1988). As noted previously, since the estimated 30-minute concentrations represent maximum values, additional statistical analysis (e.g., the 95% confidence limit) is not warranted, as it would have no relevance to the true excursion limit. The excursion limit data that was taken in the "full-shift" resilient floor tile and cutback adhesive removal study likewise indicated that the average excursion concentration would be well below 1.0 f/cc. These data and analyses demonstrated, with 95% confidence, that the excursion limit would not be exceeded. A breakdown of the excursion limit results for the four studies discussed in this report are provided in Table 2.

These results demonstrate that initial monitoring of asbestos concentrations for resilient floor covering and asphaltic cutback adhesive removal jobs using the Recommended Work Practices are unlikely to show fiber counts in excess of the action level of 0.1 f/cc or the excursion limit of 1.0 f/cc. There is no indication that the PEL of 0.2 f/cc would ever be reached when the Recommended Work Practices are followed.

The Fowler-Chatfield and ENVIRON studies encompassed a variety of building types (residential, commercial, institutional), subflooring (wood, concrete, or hardboard), geographic areas, types of installation (perimeter- or fully-adhered), manufacturers, types and composition of products, age and condition of products (including some damaged floors), relative difficulty of removal, and size and duration of removal. These studies include a number of 8-hour workdays or longer, and encompass the maximum quantity of these materials that can be removed during a full work shift using the Recommended Work Practices. The circumstances covered by the studies span the full range of likely conditions for resilient floor covering and cutback adhesive removal. The analysis of the results for these studies provides historical data to support a determination that floor mechanic and observer exposure to airborne asbestos during removal of resilient floor covering or cutback adhesive will not exceed the action level or excursion limit if the Recommended Work Practices are followed (see Table 3). Therefore, an employer should be able to rely upon these studies in lieu of conducting initial monitoring to comply with the requirements of the OSHA standard when removing resilient floor covering or asphaltic cutback adhesives in accordance with the Recommended Work Practices. Indeed, the OSHA letter, dated January 16, 1992, states that the results of these studies "may be relied upon by employers in lieu of initial monitoring, provided the conditions prevailing in the employer's current operations (eg. type and composition of resilient floor cover materials, quantity of removal, work practices and duration of removal activity) closely resemble those on which the ENVIRON studies are based."[16]

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[16] Letter from Patricia K. Clark, OSHA Directorate of Compliance Programs, to Walter D. Anderson, RFCI, and William B. King, Armstrong, dated January 16, 1992.

TABLE 1
Average Personal Monitoring Results for Floor Mechanic and Observer Exposure
During Removal of Resilient Floor Coverings and Asphaltic Cutback Adhesives
Pursuant to Industry Recommended Work Practices

Study Name and Media Removed	# of Samples Taken	Average 8-Hour TWA (f/cc)	95% Confidence Limit (f/cc)
Fowler-Chatfield Resilient Floor Tile	37	0.022	0.082
ENVIRON 1 Asphaltic Cutback Adhesive	7	0.004	0.007
ENVIRON 2 Resilient Sheet Vinyl Floor Covering	51	0.027	0.067
ENVIRON 3 Resilient Floor Tile & Adhesive	27	0.016	0.033

Notes: The mean TWA for the 122 samples is 0.022 f/cc, with a 95% confidence limit of 0.066 f/cc. These exposures are well below the OSHA action level of 0.1 f/cc.

TABLE 2
Excursion Limit Monitoring Results for Floor Mechanic and Observer Exposure
During Removal of Resilient Floor Coverings and Asphaltic Cutback Adhesives
Pursuant to Industry Recommended Work Practices

Study Name and Media Removed	# of Samples Taken	30-Minute Excursion Calculation (f/cc)	95% Confidence Limit (f/cc)
Fowler-Chatfield Resilient Floor Tile	41	0.322	N/A
ENVIRON 1 Asphaltic Cutback Adhesive	7	0.073	N/A
ENVIRON 2 Resilient Sheet Vinyl Floor Covering	51	0.426	N/A
ENVIRON 3 Resilient Floor Tile & Adhesive	24	0.052	0.191

Notes: The calculated excursion limit for the first three studies shown is not a true excursion limit, but rather represents the average of maximum possible concentrations in any 30-minute excursion interval, estimated by multiplying the net concentration by the entire sampling duration and dividing by 30 minutes. This method significantly overestimates the actual excursion concentration. As a result, calculation of a 95% confidence limit is not applicable (N/A), as it has no statistical relevance to the true excursion limit. True 30-minute excursion limit samples were only taken in the final study conducted (i.e., ENVIRON 3). The high average excursion limit for the Fowler-Chatfield study is attributable to one outlier point (2.988 f/cc).

TABLE 3

Summary of Personal Monitoring Results for Floor Mechanic and Observer Exposure During Removal of Asbestos-Containing Resilient Floor Coverings and Asphaltic Cutback Adhesives Pursuant to Industry Recommended Work Practices

Site Number[a]	PCM (f/cc)	8-Hour TWA (f/cc)	30-minute maximum (f/cc)[b]	Material Removed
1-1	0.0027-0.0126	0.0015-0.0258	0.034-0.413	Floor Tile
1-2	0.0039-0.0481	0.0025-0.0347	0.041-0.555	Floor Tile
1-3	0.0553-0.1971	0.0130-0.0522	0.240-0.834	Floor Tile
1-4	0.0106-0.0270	0.0026-0.0077	0.043-0.123	Floor Tile
1-5	0.0951-0.1842	0.0000-0.0388	0.320-0.630	Floor Tile
1-6	0.0331-0.1730	0.0144-0.0483	0.137-0.456	Floor Tile
1-7	0.0183-0.3295	0.0102-0.1867	0.164-2.986[c]	Floor Tile
1-8	0.0236-0.0840	0.0070-0.0275	0.113-0.440	Floor Tile
1-9	0.0047-0.0383	0.0019-0.0158	0.031-0.253	Floor Tile
1-10	0.0097-0.0455	0.0039-0.0261	0.063-0.417	Floor Tile
2-1	0.0054-0.0059	0.0039-0.0047	0.0429-0.0754	Adhesive
2-2	0.0113-0.0301	0.0024-0.0058	0.0377-0.0924	Adhesive
2-3	0.0053-0.0073	0.0040-0.0057	0.0702-0.1009	Adhesive
3-1	0.014-0.053	0.013-0.028	0.081-0.113	Sheet Vinyl Flooring
3-2	0.0020-0.0094	0.0013-0.0071	0.0213-0.1132	Sheet Vinyl Flooring
3-3	0.0047-0.0086	0.0035-0.0067	0.0560-0.1072	Sheet Vinyl Flooring
3-4	0.0103-0.0388	0.0074-0.0206	0.1178-0.3298	Sheet Vinyl Flooring
3-5	0.0069-0.0112	0.0056-0.0095	0.0901-0.1512	Sheet Vinyl Flooring
3-6	0.0181-0.0292	0.0147-0.0237	0.2358-0.3798	Sheet Vinyl Flooring
3-7	0.1095-0.1454	0.0358-0.0473	0.5731-0.7562	Sheet Vinyl Flooring
3-8	0.0303-0.0331	0.0168-0.0177	0.2684-0.2834	Sheet Vinyl Flooring
3-9	0.0223-0.0329	0.0177-0.0257	0.2833-0.4106	Sheet Vinyl Flooring
3-10	0.0550-0.8798	0.0081-0.0382	0.4491-0.6116	Sheet Vinyl Flooring
3-11	0.0282-0.0499	0.0185-0.0334	0.2955-0.5337	Sheet Vinyl Flooring
3-12	0.0529-0.0731	0.0403-0.0539	0.6475-0.8942	Sheet Vinyl Flooring
3-13	0.0949-0.1105	0.0775-0.0905	1.2401-1.4476	Sheet Vinyl Flooring
3-14	0.0374-0.0592	0.0311-0.0502	0.4988-0.8026	Sheet Vinyl Flooring
3-15	0.0357-0.0447	0.0110-0.0143	0.1763-0.2292	Sheet Vinyl Flooring
3-16	0.0047-0.0146	0.0035-0.0110	0.0564-0.1753	Sheet Vinyl Flooring
3-17	0.0399-0.0438	0.0312-0.0349	0.4998-0.5580	Sheet Vinyl Flooring
3-18	0.0834-0.2220	0.0202-0.0523	0.3225-0.8363	Sheet Vinyl Flooring
4-1[d]	0.0191-0.0393	0.0197-0.0341	0.0464-0.1378	Floor Tile & Adhesive
4-2	0.0138-0.0148	0.0163-0.0177	0.0416-0.0650	Floor Tile & Adhesive
4-3	0.0214-0.0235	0.0292-0.0325	No samples taken	Floor Tile & Adhesive
4-4	0.0119-0.0207	0.0114-0.0202	0.0136-0.0421	Floor Tile & Adhesive
4-5	0.0080-0.0217	0.0073-0.0212	0.0409-0.3593	Floor Tile & Adhesive
4-6	0.0090-0.0135	0.0091-0.0135	0.0230-0.0526	Floor Tile & Adhesive
4-7	0.0078-0.0098	0.0088-0.0087	0.0078-0.0334	Floor Tile & Adhesive
4-8	0.0053-0.0137	0.0047-0.0122	0.0123-0.0272	Floor Tile & Adhesive
4-9	0.0073-0.0118	0.0066-0.0108	0.0037-0.0178	Floor Tile & Adhesive

Footnotes:

Note: PCM results are adjusted for background concentration levels and measure both asbestos and non-asbestos fibers greater than 5 µm with a 3-to-1 aspect ratio. TWA and 30-minute maximum (excursion limit) results are for PCM analysis.

[a] Four independent studies of resilient floor covering and/or cutback adhesive removal were conducted at 40 different locations. The values presented represent the range of concentrations measured for two floor mechanics and at least one observer at each site.

[b] In the first three studies, a true excursion limit sample was not taken. Instead, a 30-minute maximum was calculated by assuming the net PCM concentration measured for the entire removal activity occurred within a single 30-minute period.

[c] The companion sample showed no asbestos by TEM analysis. This value is grossly inconsistent with the samples for other mechanics and observers on this and other jobs and is therefore suspect.

[d] The values shown here represent "full-shift" measurements over an 8-hour workday. The summation of individual "partial-shift" activities also did not exceed OSHA TWA or excursion limit standards.

Sources:

1. ENVIRON Corporation. April 3, 1989. Evaluation of Exposure to Airborne Fibers during Removal of Resilient Floor Tiles Using Recommended Work Practices. (Sites 1-1 through 1-10)

2. ENVIRON Corporation. March 30, 1990. Evaluation of Worker Exposure to Airborne Fibers during the Removal of Asphaltic Cutback Adhesive Using Recommended Work Practices. (Sites 2-1 through 2-3)

3. ENVIRON Corporation. March 30, 1990. Evaluation of Worker Exposure to Airborne Fibers during the Removal of Resilient Sheet Vinyl Floor Covering Using Recommended Work Practices. (Sites 3-1 through 3-18)

4. ENVIRON Corporation. September 27, 1991. Evaluation of Worker Exposure to Airborne Fibers during the Removal of Floor Tile and Cutback Adhesive Using Recommended Work Practices. (Sites 4-1 through 4-9)