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ANALYSIS OF FINAL CLEARANCE AIR SAMPLES

Final clearance air samples may be analyzed by several methods and, as an owner, administrator or manager of a building facility, it is important to know the advantages and disadvantages of the two main types. A brief description of the clearance process will help you in this understanding.

Following removal of all visible asbestos material in containment by the contractor, a final visual inspection is provided by the project manager. If visual inspection passes, the contractor is allowed to "lockdown" the area with a sealant to control unseen fibers. The containment is allowed to dry, then final clearance air samples are collected to ensure the area is clean and meets the criteria for re-occupancy.

Two predominant types of analysis used today are Transmission Electron Microscopy (TEM) and Phase Contrast Microscopy (PCM). The attached table summarizes differences between the two.

PCM ANALYSIS - ADVANTAGES

The advantages of PCM analysis include:

1. **PCM analysis includes standardization and quality control:** Standard sampling and analytical protocols are used with NIOSH 7400 method, and quality control/quality assurance established with the PAT program.

2. **PCM analysis cost is relatively inexpensive** and much less than TEM analysis.

3. **PCM analysis is readily available today** with more laboratories performing such services and having onsite analysis capabilities.

4. **PCM air sample analysis turn-around time is very fast.** Most clearance air samples are analyzed within two hours.

PCM ANALYSIS - DISADVANTAGES

Disadvantages of PCM analysis include:

1. **PCM analysis does not find all asbestos fibers:** PCM utilizes a light microscope at 400 - 450 x magnification and thus detection of very thin, small fibers (< 5 microns) is limited.

2. **PCM analysis does not differentiate between asbestos and non-asbestos fibers:** Since PCM analysis counts any and all fibers, it does not differentiate between asbestos and non-asbestos. Therefore, fiberglass, mineral wool, cotton, cellulose and any other fibrous material meeting the definition of "fiber" (greater than 5 microns in length with a length to width aspect ratio of 3:1) will be counted as asbestos. An area may fail to pass the clearance criteria due to the presence of non-asbestos fibers.

<u>TEM ANALYSIS</u> - <u>ADVANTAGES</u>

Advantages of TEM analysis include:

1. **TEM analysis provides two methods of analysis:** There are two accepted methods of TEM analysis: Yamate and AHERA. The latter is required by K-12 school districts.

2. **TEM analysis includes a quality assurance program:** Beginning in 1990 a quality assurance program was required for TEM. In 1990 the National Voluntary Laboratory Accreditation Program (NVLAP) accreditation is on-line for quality assurance.

3. **TEM analysis provides a higher degree of certainty regarding clearance:** Utilizing a magnification of 18,000 to 22,000 x, TEM analysis can detect very small fibers. TEM analysis can distinguish asbestos from non-asbestos and thus avoids giving artificially high readings, as does PCM analysis.

4. **TEM analysis can determine the type** of asbestos present in an air sample.

5. **TEM analysis is considered "state of the art"** and is the analysis of choice by the EPA and professionals. It is thought to provide more acceptable evidence in legal disputes.

<u>TEM ANALYSIS</u> - <u>DISADVANTAGES</u>

Disadvantages of TEM analysis include:

1. **TEM analysis requires specialized laboratories:** There are not as many qualified and accredited laboratories available to perform this service. Currently the closest laboratories available to serve the Sacramento/San Joaquin Valleys are located in the San Francisco Bay area. During the peak abatement season (summer) or during a natural disaster (e.g., San Francisco earthquake in October of 1989) the TEM laboratories can have difficulty meeting demands.

2. **TEM analysis requires more time than does PCM analysis:** If the lab is not local, overnight mail delivery also adds to the delay in turnaround time for sample results, thus delaying the return of the abatement area to the building owner.

3. **TEM analysis is more expensive than PCM analysis:** The cost for TEM analysis is about 4-10 times higher than for PCM analysis. On a rush basis the cost increases significantly.

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CHOOSING PCM OR TEM

School Districts with K-12 educational and maintenance facilities must follow U.S. EPA AHERA requirements. AHERA dictates when TEM must be used and when PCM may be used based on the quantity of asbestos material being removed and date of removal. The school may decide it is better in some instances to use TEM even though only PCM is required.

Owners who are not school districts with K-12 facilities are not required to follow AHERA, however, many owners have chosen to use TEM as the analysis of choice because of its specificity for asbestos.

It is generally agreed among professionals in this field that TEM analysis is better than PCM analysis and probably could be better defended in a court of law. Although TEM is arguably the best choice, sometimes PCM is used for clearances due to costs, time constraints or if only small amounts of asbestos are being removed.

In some instances there may be substantial interferences from non-asbestos fibers. For example, in an attic space with fiberglass insulation, the non-asbestos fiberglass can interfere with the final PCM clearance as fiberglass fibers are counted as asbestos fibers. Similarly, in a wood shop where asbestos is being removed, wood dust in the immediate area may interfere with PCM analysis. It may be more appropriate to use TEM analysis in such cases.

Where small sections of pipewrap are removed, e.g., less than 10 linear feet in a work area, PCM may be acceptable.

When "open abatement" removal is used instead of glovebag technique, it is probably better to use TEM analysis. With open abatement there is a greater possibility for the generation of both large and small fibers into the abatement area. Only TEM analysis can detect these very small fibers.

If non-friable ACM such as transite pipe, transite shingles, wallboard or floor tiles are removed in such a manner that they remain non-friable, then PCM analysis may be appropriate.

The decision to use TEM versus PCM for clearance purposes should be made on a case-by-case basis. This is generally decided upon prior to the start of the project and dictated in the Scope of Work. Entek, Inc. will assist you in this decision making process and the results will be incorporated in the Scope of Work. If you have read and understood these comments, please sign below.

________________________________ __________

Signature of Authorized Representative Date

COMPARISON OF METHODS FOR MEASURING AIRBORNE ASBESTOS		
	PCM	**TEM**
Standard Methods	NIOSH 7400A Method	Yamate and AHERA
Quality Assurance	Proficiency Analytical Testing Program: no NBS reference materials.	AHERA NVLAP Accreditation
Cost	$15.00 - $35.00	$ 75.00 - $ 175.00
Availability	Readily available - with onsite analysis capability	Limited availability - especially during peak season. Onsite analysis of samples **not available.**
Time Requirements	1 hr. preparation & analysis < 6 hrs. turnaround	Generally 12-48 hours. 4 hours preparation minimum; 1 hour analysis per sample
Sensitivity (Thinnest Fiber Visible)	0.15μ at best 0.25μ typical	0.0002μ at best; 0.0025μ typical
Specificity	Not specific for asbestos	Definitive for asbestos when used to its fullest capabilities. "State of the Art"

ENTEK

RECOMMENDED INTERIM GUIDELINES FOR STRIPPING ASBESTOS-CONTAINING FLOORS

The Environmental Protection Agency (EPA) recommends school officials, building owners, and custodial/maintenance staff consider the following basic guidelines when stripping wax or finish coat from asbestos-containing floor coverings:

1. **AVOID STRIPPING FLOORS.** Stripping floors should be done as infrequently as possible--perhaps once, twice or less per year, depending on circumstances. The frequency should be carefully considered as floor maintenance schedules or contracts are written or renewed.

2. **PROPERLY TRAIN STAFF.** Custodial or maintenance staff who strip floors should be trained to properly and safely operate the machines, pads, and floor care chemicals used at the facility.

3. **FOLLOW APPROPRIATE WORK PRACTICES.** Custodial or maintenance staff who strip floors should follow appropriate work practices, such as those recommended here, under informed supervision. Directions from floor tile and floor wax product manufacturers on proper maintenance procedures should be consulted.

4. **STRIP FLOORS WHILE WET.** The floor should be kept adequately wet during the stripping operation. Do NOT perform dry stripping. Prior to machine operation, an emulsion of chemical stripper in water is commonly applied to the floor with a mop to soften the wax or finish coat. After stripping and before application of the new wax, the floor should be thoroughly cleaned, while wet.

5. **RUN MACHINE AT SLOW SPEED.** If the machine used to remove the wax or finish coat has variable speeds, it should be run at slow speed (about 175-190 rpm) during the stripping operation.

6. **SELECT THE LEAST ABRASIVE PAD POSSIBLE.** EPA recommends the machine be equipped with the least abrasive pad possible to strip wax or finish coat from asbestos containing floors.

7. **DO NOT OVERSTRIP FLOORS.** Stop stripping when the old surface coat is removed. Overstripping can damage the floor and may cause the release of asbestos fibers. Do NOT operate a floor machine with an abrasive pad on unwaxed or unfinished floors.

8. **REMEMBER**: Improperly removing asbestos-containing floor covering could result in the release of high levels of asbestos. **EPA recommends** you leave asbestos-containing floor covering in place, provided the material is in good condition. However, proper maintenance procedures, such as those outlined above, should always be followed.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Prevention, Pesticides and Toxic Substances
AHERA Interpretive Guidance Workgroup
Office of Compliance Monitoring
July 1992

POLICY CLARIFICATION
FOR THE ASBESTOS HAZARD EMERGENCY RESPONSE ACT (AHERA)

ISSUE: Under what circumstances is removal of Vinyl Asbestos Tile (VAT) or similar materials a response action under AHERA?

BACKGROUND:

AHERA section 202, Definitions, states that a response action " ... means methods that protect human health and the environment from asbestos-containing material."

The AHERA schools regulation definition of response action (40 CFR 763.83) states: "Response action means a method, including removal, encapsulation, enclosure, repair, operations and maintenance, that protects human health and the environment from friable ACBM."

In defining "friable", the AHERA schools rule states: "'Friable' when referring to material in a school building means that the material, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure, and includes previous nonfriable material after such previously nonfriable material becomes damaged to the extent that when dry it may be crumbled, pulverized, or reduced to powder by hand pressure."

The response to Question 42 of the "100 Commonly Asked Questions About the AHERA Asbestos-In-Schools Rule" (May 1988) also relates to the issue. It states:

> "If the floor tile or its adhesive material does not become friable during the removal process, it is not a response action, since the definition of response action refers to a method "that protects human health and the environment from friable ACBM." If the material becomes friable during removal, however, the job is then a response action ..."

Implicit in this answer is the assumption that if the material is already friable, the activity must be conducted as a response action.

This paper seeks to clarify that certain VAT removal activities must be conducted as response actions under AHERA and that the determination of whether a particular removal activity is, or is not, a response action, needs to occur prior to initiation of the activity in order that all necessary requirements and precautions are met.

DISCUSSION:

Vinyl asbestos tile (or sheet flooring) in good condition would generally be considered nonfriable. However, it is recognized that when nonfriable ACM is subjected to certain forces, such as mechanical forces, weather, or aging, it can be weakened to the point where it can become friable (i.e., crumbled, pulverized, or reduced to powder by hand pressure) and can thereby release asbestos fibers. EPA discussed this situation in the preamble to the November 20, 1990 Asbestos NESHAP Revision and acknowledged it in the definition of "Regulated Asbestos-Containing Material". ("'Regulated Asbestos-Containing Material' is (a) friable asbestos material, (b) Category I nonfriable ACM that has become friable, (c) Category I nonfriable ACM that will be or has been subjected to sanding, grinding, cutting or abrading, or (d) Category II nonfriable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder by the forces expected to act on the material in the course of demolition or renovation operations."[1]

The AHERA schools rule also recognized the potential for nonfriable material to become friable in both its definition of friability and in 40 CFR 763.91(a): "Any material identified as nonfriable ACBM or nonfriable assumed ACBM must be treated as friable ACBM for purposes of this section when the material is about to become friable as a result of activities performed in the school building."

The use of certain mechanical techniques on VAT or asbestos-containing sheet flooring (and the mastic used to hold it in place), such as sanding, grinding, chipping, drilling, cutting,[2] and abrading, create a high probability that ACM will be damaged or weakened to such an extent that it would be rendered friable. Based on the AHERA regulation's definition of response action as "a method that protects human health and the environment from friable ACBM", and the expectation that the material will be rendered friable by the activity, if any of these methods are employed to remove VAT from an AHERA-regulated school building, the activity would be considered to be a response action (unless it is a small-scale-short-duration project). In addition, the asbestos NESHAP requirements, including notification, may apply to the activity.

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[1] Category I nonfriable ACM is any asbestos-containing packing, resilient floor covering (and mastic), or asphalt roofing product which contains more than 1 percent asbestos as determined using polarized light microscopy (PLM). Category II nonfriable ACM is any material, excluding Category I nonfriable ACM, containing more than 1 percent asbestos as determined using PLM, that, when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure. (40 CFR Part 61 Subpart M, Sec. 61.141)

[2] In this context, "cutting" does not include shearing, slicing, or punching.

However, at this time, it appears that certain other removal techniques which do not use grinding, mechanical chipping, abrading, cutting, sanding, or drilling the material would not be expected to render the material friable. (Examples of such techniques include those which use solvents, water, or heat – such as infra-red, or other similar techniques, which cause the tiles to become loosened or pliant to the point where they are easily removed.) These activities would not be considered to be response actions, as long as the material is not already friable, or in such poor condition that it is likely to become friable during the activity, or as a consequence of the activity.

In summary, in deciding whether or not to conduct a removal activity (other than small-scale-short-duration) as a response action (including use of a project design, accredited persons, and air clearance), both of the following factors must be considered.

1) Condition of the material. If the material is in such poor condition that it is already friable, or that it is likely to become friable during, or as a consequence of the activity, the removal must be conducted as a response action, because of the high probability of fiber release from the friable material.

2) The methods which will be used to remove the material. (including the mastic). If the removal methods involve sanding, grinding, drilling, mechanical chipping, cutting[3], or abrading the material, or any other technique that is likely to result in rendering the material friable, the removal must be conducted as a response action.

In addition to fulfilling AHERA requirements, consideration of these factors is consistent with the requirements of the Asbestos NESHAP.

DETERMINATION:

Removal of VAT (or other known or assumed ACM flooring or its adhesive) which involves sanding, grinding, mechanical chipping, drilling, cutting[4], or abrading the material has a high probability of rendering the material friable and capable of releasing asbestos fibers. Therefore, removal projects which employ any of these techniques (other than small-scale-short-duration) must be conducted as response actions, including use of a project design, accredited persons, and air clearance.

In addition, any removal project should receive careful planning prior to initiation in order to determine whether it needs to be conducted as a response action. While this paper is directed primarily at clarifying which removal activities must be conducted as response actions, removal techniques for small-scale-short-duration projects should also be evaluated prior to initiation to ensure that they, too, are conducted safely.

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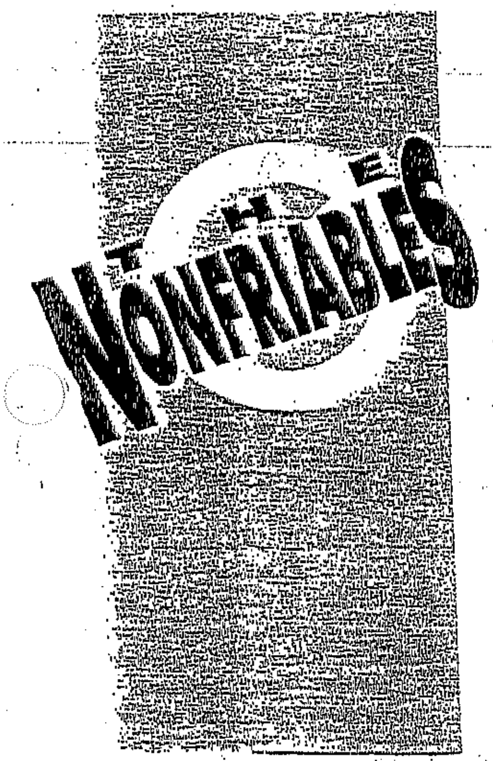
[3] See footnote #2.

[4] See footnote #2.

No matter what the removal technique or scope of the project, consideration should be given to worker and building occupant protection (including OSHA and EPA Worker Protection requirements and state regulations), proper disposal of removed material, and final cleaning of the work area. Thought should also be given to the potential for releases of VOCs (volatile organic compounds) from solvents; fire hazards; and possible hazardous waste considerations from the use of solvents such as toluene and xylene to remove mastic. In addition, NESHAP requirements apply to any project, or group of projects at a facility, planned or anticipated within a calendar year which will reach the NESHAP threshold (160 square or 260 linear feet).

ASBESTOS ISSUES

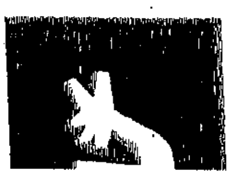
May 1991



VAT: How Safe To Maintain?

A Study of Airborne Asbestos Concentrations During Routine Floor Maintenance Activities

By Timothy J. Marxhausen and Stephen A. Shaffer
Forensic Analytical Specialties Incorporated
Hayward, California



VINYL ASBESTOS TILE:
A Study of Airborne Asbestos Concentrations During Routine Floor Maintenance Activities

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INTRODUCTION

Reams of data exist regarding airborne asbestos concentrations during various asbestos containing material (ACM) handling, removal and maintenance activities. And although vinyl asbestos tile (VAT) buffing and scrubbing actions may be the most common of asbestos material maintenance activities, performed thousands of times daily in the United States, relatively little air sampling data exists for these activities.

Only recently have we questioned whether asbestos fiber release occurs as VAT surfaces are scrubbed with abrasive, friction generating floor maintenance equipment. Data from a limited number of past samplings, and the data presented here, indicate alarming concentrations of airborne asbestos structures during routine VAT maintenance activity.

Our interest in this subject was piqued by a public school district client's air sampling during some of their regular floor maintenance operations. The samples were originally submitted for PCM analysis, and, upon hearing of the sampling situation, we decided to reanalyze the samples by TEM. The results were astounding.

Table 1 presents the school district sampling data. Essentially, the air samples were gathered during normal, routine floor maintenance procedures. Area samples were collected in school cafeterias and classrooms during each activity. Equipment or room surfaces were not cleaned prior to sampling, raising the question as to pre-existing contamination and thus the validity of sample results.

TABLE 1
VAT MAINTENANCE STUDY
AIR SAMPLING BY SCHOOL DISTRICT PERSONS
WINTER/SPRING 1989 - 1990

Location	Volume (liters)	TEM st/cc	TEM st/mm²	PCM f/cc
Stripping (Black pad)	1690.5	1.51	6619.7	N.A.
Stripping (White pad)	1800	0.224	1046.2	0.054
Stripping (Mop and bucket)	2625	0.281	1916.6	0.007
Low Speed Scrub (Red pad)	1755	0.044	201.2	0.017
High Speed Scrub	2025	0.805	4236.1	0.018

One sample analyzed by TEM for each activity. Samples collected during normal school floor maintenance operations.

N.A. = Not Available

Based on this data and in consultation with the school district, we decided to conduct field experiments during routine VAT maintenance operations[1].

STUDY DESIGN PARAMETERS

Measures were taken to minimize or eliminate the pre-existing contamination and the potential for airborne asbestos contamination from sources other than the floor maintenance activity. We also decided to examine the floor tile surfaces under the Scanning Electron Microscope (SEM) at various stages of maintenance and condition. The study parameters were:

1. Measure airborne asbestos concentrations resulting from typical, routine VAT maintenance activities.

[1] Facilities, maintenance equipment and supplies, and guidance on routine maintenance practices for this study were graciously provided by Mr. Bob White of the Hayward (California) Unified School District. They also contracted for the construction of containment and decontamination facilities and the use of HEPA filtration equipment. Forensic Analytical Specialties, Inc. provided all labor, air sampling, and analytical work for the study.

2. Employ equipment and procedures typically used. Do not modify or alter normal routine floor maintenance practices or equipment.

3. Perform activities on nine inch square VAT, installed in the 1950s and 60s.

4. Activities done in two school classrooms, each approximately 900-1050 square feet in size.

5. Asbestos content of the floor tiles: 20-30% (TEM bulk analysis).

6. Collect pieces of VAT at each stage of floor maintenance for surface examination by (SEM).

Our study did not address, or attempt to address, comparisons of various floor tile maintenance and finishing products or practices, asbestos exposure epidemiological issues as related to custodians or building occupants, or asbestos fiber release during VAT removal.

FLOOR MAINTENANCE ACTIVITIES

As we discussed floor maintenance procedures and activities with the school district personnel, it became evident that practices and procedures can vary. While floor maintenance is not a complex process, there are numerous floor care and floor finish products and slightly different scrubbing/buffing methods (abrasive pad type and water use being the main variables). The types of floor maintenance activities and equipment used during the study are outlined below.

High Speed Scrub

High speed scrubbing cleans the floor of surface dirt and freshly polishes the surface. This is typically done once or twice a week. A high speed buffing machine operating at 1000 - 1500 rpm is used with a white pad (least abrasive). A neutral cleaning solution is misted onto the floor surface during the buffing operation.

Low Speed Scrub

Low speed scrubbing cleans floor of surface dirt. It is performed less frequently and on floors more dirty and worn than those subjected to high speed scrub. A low speed buffing machine operating at 150 - 200 rpm with is used with a red pad (medium abrasiveness). A neutral cleaning solution is mopped onto floor prior to scrubbing. After the scrubbing, the solution is mopped up from the floor.

Stripping

Stripping is used to remove all waxes, sealants, and floor finishes. It is done infrequently, approximately every three to four years. A low speed buffing machine is used with a black pad (most abrasive). A very alkaline (pH 10-12) stripping solution is liberally mopped onto the floor, the floor is scrubbed with the black pad, and the residue solution is mopped up from the floor. A rough, bare vinyl floor tile surface is left, ready for refinishing. A no-rinse stripper was used in this study.

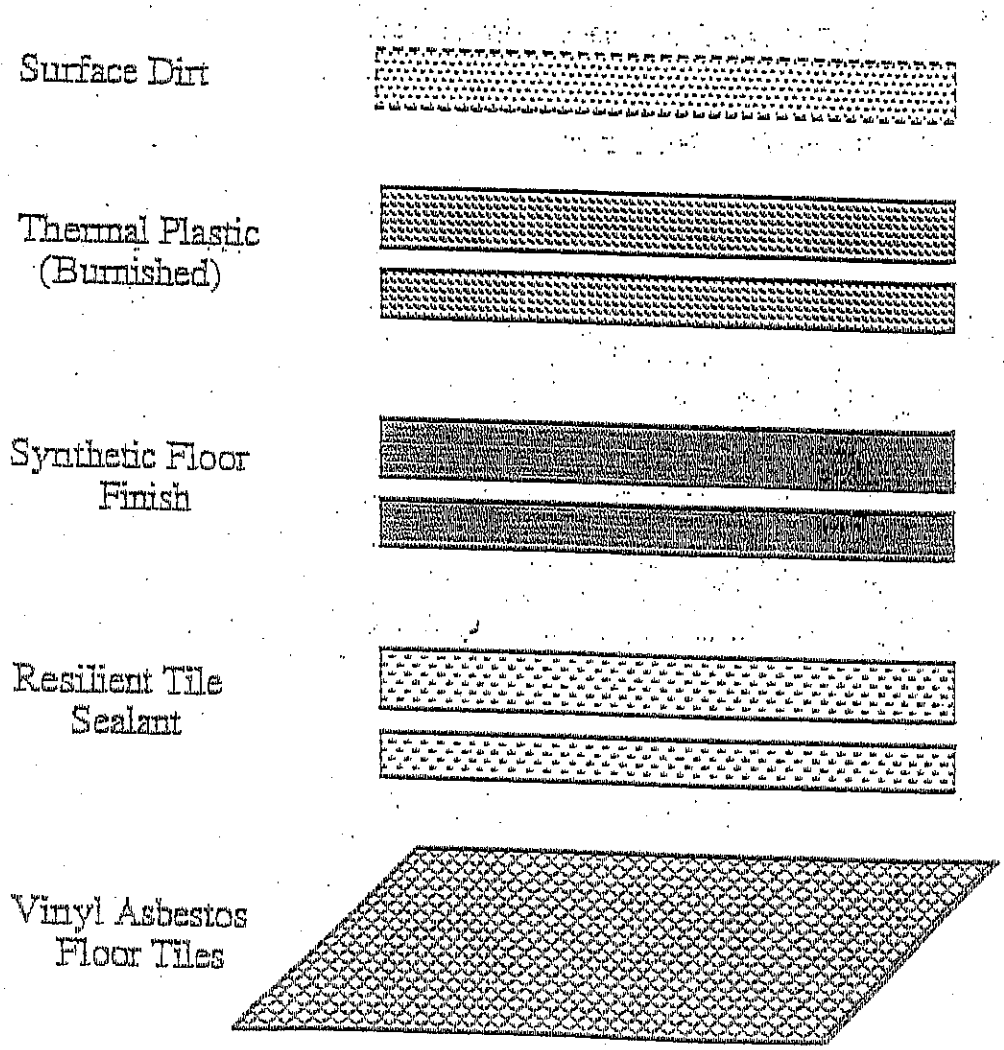
Floor Finish Build-Up

A complete floor finish consists of three different finish products which are mopped onto the floor and allowed to dry before the next application. The complete, new floor finish consists of a minimum of six layers, two each of sealant, base coat, and thermal finish coat. Figure 1 illustrates the floor finish layers.

Figure 1

Vinyl Asbestos Floor Tile Maintenance Study

Floor Finish Profile



EQUIPMENT AND PRODUCTS

All of the equipment and products used in this study were of types and brands in routine use by the Hayward Unified School District.[2] The products used included the following.

- General Floor Machine "Bobcat" unused low speed (150 - 200 rpm) and "Couger" unused high speed (1000 - 1500 rpm) buffing machines
- Norton Company "Bear-Tex, Super 54" brand white and red, 20" floor maintenance pads
- "Brillo" brand 20" black stripping pads
- New and unused mop bucket, new mop heads for each floor finish treatment or cleaning process
- National Sanitary Supply Company floor finish and treatment products, including:

  "Cinch No Rinse Stripper"
  "Acrathane Resilient Floor Sealer"
  "Thermal System Base Coat"
  "Thermal Restorer"

- Hillyard Chemical Company "Top Clean" brand cleanser was used during high speed and low speed scrub activities

CONTROL MEASURES EMPLOYED DURING THE STUDY

A series of engineering, safety, and quality control measures were employed during the study in order to insure the integrity of the data collected. These will be briefly described.

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[2] Use of commercial brand names does not constitute any indorsement or comment on the quality of these products. They are identified only to reflect that commercial products in common use were employed in this study.

Containment and Decontamination Unit

A conventional asbestos removal containment consisting of polyethylene on room walls and ceiling was constructed in the study rooms. A three stage decontamination unit with a wet shower at the entrance to work areas was also included. High-volume (1500 cfm) HEPA filtration units were employed within the containments to clean and purge the room air following each test activity. Figure 2 illustrates the site layout.

New Equipment and Supplies

In every instance, new and previously unused products were employed in order to avoid the danger of contamination from previously used products. Buffing machines were direct from the manufacturer's container.

Air Sampling Strategy

Three air samples were collected during each test process. Baseline and post-activity samples were collected under aggressive sampling conditions to insure that all test results reflected airborne concentrations resultant from the test activity alone. Outside, area samples were collected during all test operations, as were field blank cassettes.

Air sample collection began at the start of each test activity and concluded approximately one hour after completion of the activity. Flow rates ranged from 6 to 10 liters per minute. Sample cassettes were positioned approximately four to five feet above the floor surface. Sample cassettes meeting AHERA clearance design specification were used. Post-activity "clearance" samples were collected after each test activity and prior to beginning the next test activity.

Laboratory Analysis and QA/QC Measures

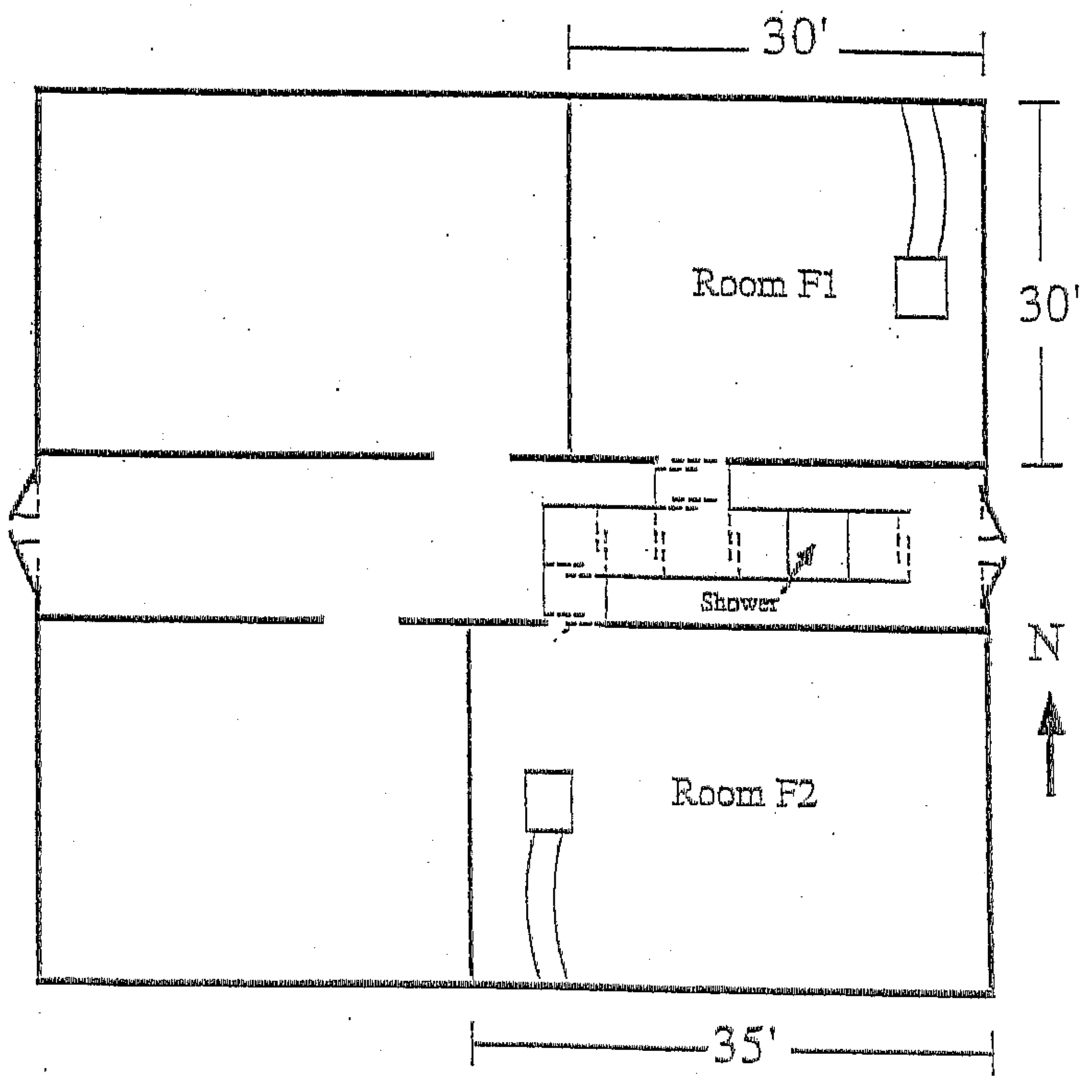
All samples were analyzed by transmission electron microscopy (TEM) following AHERA counting rules. Selected samples were also analyzed by phase contrast optical microscopy (PCM) following the NIOSH Method 7400, Revision 3. Scanning electron microscopy (SEM) did not follow any established analytical protocol since the purpose of these examinations was to document surface texture and appearance only.

Extensive laboratory QA and QC measures are in routine use at Forensic Analytical and were employed in this study. Laboratory and field blanks are prepared with each sample set and a minimum of ten percent of all samples are re-prepared and reanalyzed internally. In addition, for this study a minimum of ten percent of the samples were sent to an external laboratory for

Figure 2

Vinyl Asbestos Floor Tile Maintenance Study

Site Layout



independent reanalysis.[3] Other routine QA measures include participation in external proficiency testing and verified counting exercises, as well as internal verified counting and library sample analyses.

Over seventy air samples were analyzed by TEM as part of the study. Internal reanalyses were all within acceptable limits. Two external reanalyses were outside of acceptable limits of variation[4]. Six of the field blanks were analyzed. All showed less than two asbestos structures detected.

AIR SAMPLING RESULTS

After containment construction but prior to any floor maintenance activities, baseline samples were collected in each room under aggressive sampling conditions. Results are presented in Table 2.

TABLE 2
VAT MAINTENANCE STUDY
BASELINE AIR SAMPLES

Location	Volume (liters)	TEM st/cc	TEM st/mm^2	PCM f/cc
Room F1	2018	0.0015	8.167	0.005
Room F2	2027	N.D.	N.D.	0.005
Outside building	2009	N.D.	N.D.	0.001

Results are average of three samples. Inside room samples collected under "aggressive" sampling conditions.

N.D. = None Detected

[3] The capable assistance of Dr. Jim Millette and Mr. Keith Wheeles of Millette, Vander Wood Associates in Norcross, GA is gratefully acknowledged.

[4] Acceptance criteria for sample reanalyses are designed so that a well controlled laboratory will produce repeat analyses which are within acceptable limits 95% of the time. While up to 5% of such reanalyses may be expected to fall outside of such limits, the occurrence of two such failures in 20 reanalyses (10%) is cause for concern and efforts are underway to determine the source of the variations observed. Contact the authors for further information.

Air sampling results for each test activity are presented in Tables 3 - 7. PCM data is presented where available solely for comparative purposes.

Tables 3 and 4 reflect data gathered during low and high speed scrubs on floor surfaces as received. The floor finish and activity histories for the test rooms were not known, however district personnel indicated that the rooms had typical histories for classrooms within the district.

TABLE 3
VAT MAINTENANCE STUDY
AIR SAMPLING DURING LOW SPEED SCRUB (RED PAD)

Location	Volume (liters)	TEM st/cc	TEM st/mm^2	PCM f/cc
Room F1 as received	623.5	0.069	110	0.0215
Outside building	879	N.D.	N.D.	0.010

Room F1 results are average of three samples.

N.D. = None Detected

TABLE 4
VAT MAINTENANCE STUDY
AIR SAMPLING DURING HIGH SPEED SCRUB (WHITE PAD)

Location	Volume (liters)	TEM st/cc	TEM st/mm^2	PCM f/cc
Room F2 as received	833.7	0.533	1067.5	0.016
Outside building	693	N.D.	N.D.	N.A.

Room F2 results are average of three samples.

N.A. = Not Available
N.D. = None Detected

Air sampling during stripping operations, during which all floor finish layers were removed, is summarized in Table 5.

TABLE 5
VAT MAINTENANCE STUDY
AIR SAMPLING DURING STRIPPING (BLACK PAD)

Location	Volume (liters)	TEM st/cc	TEM st/mm²	PCM f/cc
Room F2	957.9	1.450	3625.2	0.0045
Room F1	1814.8	1.153	462.9	0.007
Outside building	1860.1	0.0021	13.9	0.001

Room F1 and F2 results are average of three samples.

After the stripping operations, the floor finish was built-up with two layers of sealant, two layers of base coat and two layers of thermal plastic. The final two layers of thermal plastic are dry-buffed with a white pad to cure and buff the finish to a luster. Samples collected during the burnishing operation are presented in Table 6.

TABLE 6
VAT MAINTENANCE STUDY
AIR SAMPLING DURING HIGH SPEED BURNISHING (WHITE PAD)

Location	Volume (liters)	TEM st/cc	TEM st/mm²	PCM f/cc
Room F1 after finish build-up	1080	0.069	194.4	N.A.
Outside building	1750	N.D.	N.D.	N.A.

Room F1 results are average of three samples.

N.D. = None Detected
N.A. = Not Available

High speed scrubs are routinely performed on floor finishes over the thermal plastic layer. Table 7 summarizes the sampling on two freshly built-up finishes and the worn finish in the test rooms as received. Airborne concentrations during high speed scrubs differed significantly between as-received surfaces and freshly built-up surfaces. This may reasonably be explained by the abrasive wear and tear that aged floors have been subjected to since they were freshly finished.

TABLE 7
VAT MAINTENANCE STUDY
AIR SAMPLING DURING HIGH SPEED SCRUB (WHITE PAD)

Location	Volume (liters)	TEM st/cc	TEM st/mm^2	PCM f/cc
Room F2 as received	833.7	0.533	1067.5	0.016
Room F2 after finish build-up	1375.6	0.111	393.5	N.A.
Room F1 after finish build-up	1030.2	0.130	347.2	0.034
Outside building	1659.6	0.0014	9.3	N.A.

Results are average of three samples

N.D. = None Detected
N.A. = Not Available

SEM SURFACE EXAMINATION RESULTS

Pieces of floor tiles approximately 2 inches square were collected at the outset of the study and after each test activity. These were examined by SEM to determine their surface texture and whether any asbestos could be seen at the exposed surface of the tile. Selected photomicrographs are presented for their aesthetic value only. No generally accepted procedure exists for the positive identification of asbestos minerals in the SEM. Based on morphology and size, we assume the fibrous structures seen in the images are asbestos bundles. There also appear to be fibers lying in the smoother surfaces of the coated tile samples. Figures 3 through 6 are are paired SEM images of various test surfaces. In each case the upper photograph is at 5000 times magnification and the lower photo is at 500 times magnification. Figure 7 is a composite of four images, all at 500 times magnification. Each is further described below.

Figure 3 shows a non-asbestos floor tile surface for comparison to the photos that follow.

Figure 4 shows one of the VAT surfaces as received and before any test activities.

Figure 5 shows a VAT surface as received but after a high speed scrub test. This floor has not been stripped. Notice in Figures 4 and 5 the scored and abraded appearance of the surface. While it is clear that some finish remains on the surfaces of these tiles, it is also clear that there are heavily abraded areas where underlying vinyl tile surface may be exposed.

Figure 6 shows a VAT surface after stripping. Note that a free fiber bundle is prominently exposed in the center of the image area.

Figure 7 is a composite of four images which represent the unfinished floor surface, then the appearance of the surface after application of two coats of sealant, two coats of base coat, and two finish coats of burnished thermal plastic. Note the existence of sub-micron size fibers which may be asbestos in the surfaces of the second and third images. Also note on the freshly finished surface, the last image, that the surface is smooth and that all areas are covered. As the floor is subjected to wear and routine maintenance, this surface would degrade to something like that shown in Figure 4.

CONCLUSIONS AND DISCUSSION

Our test series confirmed what had been suggested by the school district's initial testing. Significant levels of airborne asbestos can be generated during routine VAT maintenance activities. Concentrations were lowest during low speed scrubs and the burnishing of freshly built-up, new floor finishes. High speed scrub results were highest on the worn (as received) floor but dropped to approximately one-fifth this level on freshly built-up surfaces.

Approximately 97% of the asbestos structures observed during all analysis were less than five microns in length and would not be detected or counted by PCM analysis. PCM results suggest that the OSHA action level of 0.1 f/cc would not be reached in typical maintenance operations, but the TEM analyses clearly show that significant levels of asbestos are present in the air.

As with most experiments, all did not go as planned. The drying process for the finish coats was hampered by the containment conditions and limited ventilation. This problem was alleviated by operating the differential pressure machines during finish layer applications.

The slowed drying process provided insight into what might happen if procedures are not strictly followed. The first attempt at thermal plastic (finish coat) application did not dry completely before high speed burnishing began. Air sample results from this improper burnishing process averaged 0.777 st/cc. The finish was damp and tacky at the start of buffing and dried from the friction of the pad. Data presented in table 6 represents conditions during proper buffing of dry thermal plastic layers.

High speed scrubs involve the same equipment as burnishing (high speed machine and white pad), but employ the use of a neutral cleaning solution misted onto the floor ahead of the buffer. However, results of the high speed scrub operations were significantly higher than the burnishing operations. It may be that this is due to the worn conditions of the floor surface tested during burnishing or that the limited amount of cleaning solution causes the higher values observed during high speed scrubbing operations.

The magnitude of this problem, given the huge amount of VAT in place in buildings and the limited knowledge many maintenance personnel have on this subject, suggests that this should be one of the highest priorities addressed in the asbestos industry. We would like to see this study repeated and extended to other materials and related operations. With proper funding and facilities available a more complete understanding of the causes and control of asbestos fiber generation during VAT maintenance could be developed.

It is clear that our understanding is limited, but that there is ample reason for concern about potential hazards associated with these operations. Operations and maintenance plans and personnel must address the potential hazards posed by VAT materials in a conservative manner until a better understanding of how to control the problem is developed. An issue of this nature is simply too important to ignore.

ENTEK

VAT REMOVAL

The purpose of this communication regarding the removal of vinyl asbestos floor tiles (VAT) is to provide assistance in making sense of the various regulations and in coming to a decision that best suits your individual circumstances.

Well-informed LEA Designees and building managers are aware that it is very difficult to make one's way through the different government agency's regulations regarding the removal of VAT. For the LEA Designee and building manager the issues are: (1) can the building/school untrained maintenance staff legally remove the VAT or does the removal have to be done by an accredited and registered asbestos abatement contractor? (2) What level of protection for asbestos workers, building occupants, and the environment is required? (3) Will the area have to be cleared by air samples and transmission electron microscopy (TEM) analysis if it is over 160 ft^2 or can it be cleared by phase contrast microscopy (PCM) or perhaps not cleared at all?

A cursory reading of the current regulations could lead one to the conclusion that anyone (i.e., non-accredited, non-registered, and "untrained" personnel) can remove VAT, that he/she can do so without worker protection, and without setting up a containment. Nor is it necessary to do any air-clearance sampling. And the VAT can be disposed of in any landfill that will accept them. All of this is true IF the VAT are not in poor condition, or made friable during removal, and if they do not release significant numbers of fibers. On the basis of existing research, from data gathered from abatement activities Entek, Inc. has supervised, and from data obtained from Forensic Analytical Specialties, Inc. (a laboratory), Entek, Inc. has concluded that there is a high probability that during the abatement of VAT's fiber levels in excess of the Cal/OSHA permissible exposure level (PEL) of 0.1 f/cc may be released. On the basis of these data and research it is the belief and, therefore, the policy of Entek, Inc. that VAT's should be removed from within a containment utilizing negative air devices, by accredited contractors/workers, wearing respirators and protective clothing. Moreover, we recommend that clearance air sampling be done in accordance with AHERA regulations: PCM analysis if under 160 ft^2 and TEM analysis for areas over 160 ft^2. Let us, however, review the different regulations that will affect your decision.

NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP - Environmental protection Agency - 40 CFR Part 61, November 20, 1990)

According to the EPA-NESHAP regulations "packings, gaskets, resilient floor coverings (VAT), asphalt roofing products" are not subject to NESHAP regulations *unless* they are in "poor condition" (i.e., the binding of the material is losing its integrity as indicated by peeling, cracking or crumbling) before abatement/removal, or they are made friable during removal or demolition. Thus, if your VAT are in good condition and can be removed without pulverizing them or reducing them to powder (just breaking them does not make them "friable") then the abatement activity is not regulated under NESHAP.

If the removal were covered by NESHAP regulations, EPA and/or the local Air Quality Control Agency would have to be notified, wet removal methods would be required and special disposal requirements would be imposed. But in any case if the amount of VAT to be removed is less than 160 ft^2, it does not fall under NESHAP regulations.

ASBESTOS HAZARD EMERGENCY RESPONSE ACT AHERA - EPA 40 CFR, Part 763, October 30, 1987, Asbestos-Containing Materials in Schools)

According to EPA, the removal of VAT is not a "response action' because VAT's are not a friable material. If it is not a "response action," then the removal of VAT's does not have to be done by "accredited" persons. Removal does not have to be done in a containment, and no worker-protection regulations are triggered. No clearance air samples are required. Non-friable VAT's do not have to be disposed of in labelled bags or go to designated disposal sites. BUT, as is the case under the NESHAP regulations, if the VAT become friable during removal, the status of the operation would change from non-response action to "response action," i.e., " ... a method ... that protects human health and the environment from friable ACBM" (emphasis added). If it is a response action, and there is more than approximately 3 ft^2 of material, then all regulations pertaining to the use of accredited persons, proper work practices (containments, negative air devices, etc.), worker protection, disposal at designated disposal sites, and clearance air sampling would apply. Since October 8, 1990, if the amount of asbestos-containing material within the containment barriers exceed 160 ft^2 or 260 linear feet it must be cleared by TEM analysis of air samples. Below those amounts PCM may still be used. TEM clearance will cost approximately $750.00 as opposed to approximately $125.00 for PCM per containment.

In schools (to which the AHERA regulations apply) if the amount of friable asbestos-containing material is less than approximately 3 ft^2, then it may be removed by school maintenance personnel who have received 16 hours of training. However, all the protection to human health and the environment enumerated in AHERA, Appendix B (Work Practices and Engineering Controls for Small-Scale, Short-Duration Operations Maintenance and Repair) must be observed.

If the amount of asbestos-containing material is less than 50 lbs. or it is a non-friable material, the Department of Health Services (DOHS) regulations allow material to be transported by the generator to the landfill without a waste manifest.

CAL-OSHA, CONSTRUCTION SAFETY ORDERS Title 8 California Administrative Code Section 1529: Asbestos Regulations.

At the very least one can say that the Cal-OSHA regulations can be confusing. To begin with, "asbestos containing construction material", which means any manufactured construction material which contains more than 1/10 of 1% asbestos by weight. To confuse the issue more, changes to the definition of "asbestos containing material" (ACM) were made effective July 2, 1996, and means any material containing more than

1% asbestos. AHERA and NESHAP regulations also define it as material containing "more than 1%" asbestos. Therefore, if you have VAT that contain "trace" amounts of asbestos, it is necessary to consider whether Cal-OSHA regulations would apply.

Under Cal-OSHA regulations, if the disturbance of any amount of asbestos releases 0.1 fibers per cubic centimeter (f/cc), the PEL has been reached and training and medical surveillance must be provided to the workers. Air monitoring must be done and medical and air monitoring records maintained. It should be noted that the OSHA PEL far exceeds the AHERA standard of 0.01 f/cc for occupancy after a response action.

In addition, other requirements by Cal/OSHA apply when the PEL of 0.1 f/cc is exceeded. They include: regulated areas, engineering controls (containment, negative air devices), respirators, protective clothing, and required work practices must all be met.

The question that has to be considered then, particularly if dealing with more than small-scale amounts, is whether there is a likelihood that the fiber releases will reach 0.1 f/cc. This brings us to a discussion of issues and data having a bearing on VAT fiber releases.

Attached you will find a discussion on the differences, advantages, and disadvantages of analysis of samples by phase contrast microscopy (PCM) and transmission electron microscopy (TEM), but here the relevant points can be briefly summarized. TEM is by far the more sensitive method for analysis of both bulk and air samples. VAT bulk samples that are analyzed by polarized light microscopy (PLM) and appear to contain less than 1% or only trace amounts of asbestos can be shown by TEM analysis to contain substantial amounts of asbestos.[1] Entek, Inc. encountered an illustration of this phenomenon. Three samples of a 12" VAT were taken and analyzed twice by PLM and two samples were analyzed by TEM:

	PLM (1st analysis)	PLM (2nd analysis)	TEM
No. 1	1-5%	0	10%
No. 2	0	0	not analyzed
No. 3	1-5%	trace	7%

1 The asbestos content of VAT usually ranges from 8 to 30 percent by weight. Peter H. Anderson, et al, "Analysis of Fiber Release from Certain Asbestos Products," Dec. 1982, Draft Final Report prepared for U.S. Environmental Protection Agency

Similarly, air samples taken during abatement and analyzed by PCM can show fiber releases well below the action levels, while analysis of the same samples by TEM find fiber levels well above the PEL. In a study done comparing PCM and TEM results, the author found:

> Use of TEM analytical methods during this study have shown that PCM analysis is not an effective indicator of actual asbestos fiber levels. Results from work area samples analyzed by PCM were commonly 0.01 f/cc or less. However, TEM levels measured in this study ranged from 0.015 f/cc to 1.21 f/cc in the work area during removal. Work area fiber concentrations such as these rule out the use of untrained, unprotected workers performing removal activities. Due to the elevated fiber levels encountered during this study, cost cutting measures (untrained workers, open environment, minimum air monitoring) cannot be taken.[2]

In their review of the research William H. Spain et al found the same differences between PCM and TEM results:

> During most tile and mastic removal projects, contractors seem to be very efficient in keeping the phase contrast microscopy (PCM) fiber count for personal and area samples at or below 0.1 fibers per cubic centimeter (f/cc). However, experience and reported data show that there is often difficulty getting transmission electron microscopy (TEM) results below the typical clearance level of 0.01 f/cc. especially when the samples were collected under aggressive clearance techniques. Such TEM clearance samples results are often found as high as 0.1 f/cc. In one case, 3.0 f/cc was reported. Analysis of the fiber sizes detected by TEM has shown that most of the fibers are less than 5 microns in length.[3]

According to Anderson et al[4] in their review of studies of installation, maintenance and removal of various asbestos-containing products, air samples taken during removal of VAT were measured by the less sensitive PCM method to be in excess of the CAL OSHA 0.1 f/cc PEL (0.062 to 0.147 f/cc).

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2 R. Wayne Crandlemere, Kevin P. McCarthy and Amy B. Ginsberg: "Assessment of Vinyl Asbestos Floor Tile Removal Techniques with Analysis by PCM and TEM, " Paper read at The World Congress II and Exposition on Asbestos Abatement, May 1988.

3 "Removal," Asbestos Issues, September 1989, p. 82

4 Op. cit.

John Jenkins concluded from his study of VAT removal in classrooms:

1. A significant amount of asbestos fiber is released during removal.

2. Fiber control methods such as damp removal or isolation of areas by plasticizing and use of respirators should be used for tile removal.

3. Areas subjected to contamination by tile removal using uncontrolled methods should be thoroughly cleaned and tested prior to returning to use.[5]

Mark DeLisle found in his study of five different methods of removal of VAT that regardless of method the fibers released during removal "warranted the use of containment areas and negative air machines."[6] He found, as did the other researchers, that bulk samples of VAT when analyzed by TEM showed considerably higher asbestos content than when analyzed by PLM.

As we have tried to indicate, part of the problem in determining one's course of action in regard to VAT is the method of analysis one uses. There is the initial problem of determining the percentage of asbestos in the bulk samples. PLM analysis may indicate no asbestos or much lower levels of asbestos than TEM analysis indicates. But PLM is the analysis of choice (and for AHERA). Often, therefore, the asbestos content of the VAT is much higher than it is thought to be and the potential for release of asbestos fibers much greater than anticipated.

NESHAP and AHERA regulations do not cover the removal of VAT if they are not in "poor condition." Only OSHA and CAL OSHA would regulate their removal if fiber counts reach the PEL of 0.1 f/cc as measured by PCM analysis. Yet we know that by utilizing the more sensitive TEM analysis often much higher levels of fiber releases are detected than by the PCM method. In part this is because TEM can detect smaller fibers than can be detected by PCM, and VAT tend to have, because of their manufacturing process, smaller fibers.

In the opinion of Entek, Inc. it requires too many wishful-thinking assumptions based on PLM and PCM results to ignore the likelihood that there will be significant fiber releases during the removal of VAT. We continue, therefore, to recommend that VAT be removed from within full containment, utilizing negative air devices and AHERA accredited workers wearing respirators and protective clothing. We also recommend that air clearance criteria for VAT be the same as AHERA requires for other asbestos-containing materials.

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5 "Asbestos Fiber Release from VA tile," NAC Journal, Summer Issue 1985, pp. 12-13, p. 13.

6 "Evaluation of Alternative Removal Methods for Vinyl Asbestos Floor Tile," DeLisle Associates, Ltd., 1988

Entek, Inc. has been involved in numerous asbestos abatement projects overseeing the removal of VAT and mastic, including collection of air samples. We have experienced on many occasions, where the final "clearance air samples" have failed using TEM analysis. These failed clearance air sample sets were following removal of VAT and mastic within a full poly containment enclosure covering the walls and ceiling. All work conducted by the asbestos contractors included standard "spud bars" to lift tiles, wetting techniques, followed by a solvent to remove the mastic. After mastic was removed, the entire containment was "locked down" with an encapsulant, generally using an airless sprayer.

Evidence of the release of significant number of asbestos fibers during abatement of VAT and mastic has been found by Entek, Inc. during our field experience. This has provided us with additional support of project design requirements, including complete poly enclosure of walls and ceiling, compared to some practices still used today where poly "splash guards" are employed on the lower wall surfaces.

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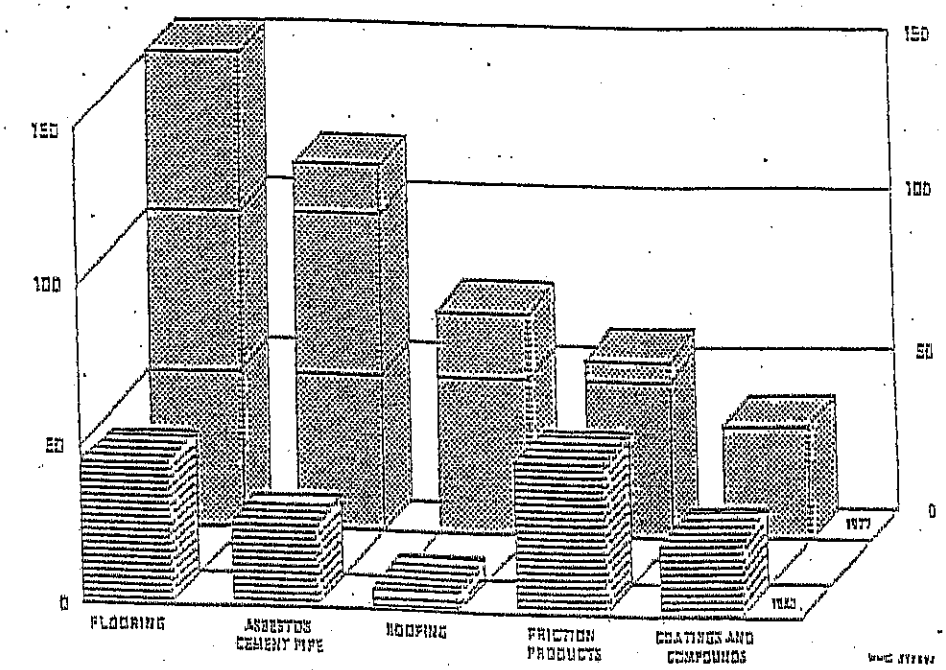
TECHNICAL

The Release of Asbestos Fibers From Asbestos Containing Floor Tiles

H.S. MacDonald , V.M. Kushnaryov, and S. Kolinski

Since the application of AHERA regulations, it has become important for analytical laboratories to become proficient in the assay of asbestos in both friable (crushable between thumb and forefinger) and non-friable materials, such as vinyl asbestos and asphalt asbestos tiles. The measurement of asbestos within tiles is difficult, (as presented by C. Wade Mullin, Environmental Contractor, Vol. 3, Issue 2, February, 1988). Two questions arise from the recent situation: How much asbestos is there in tiles? And, how much might be expected to be released during the natural life of the tile? There are many aspects to both questions. To the first questions, what is the measurement method of choice? The answer to this is not yet known. The answer to the second question one which we have started to address.

In talking to those interested in the application of these recent regulations, school janitorial staff; abatement contractors; industries which are associated with the installation of equipment (requiring drilling for example); and flooring specialists; we decided to model in the laboratory, and then gain "field figures" for the release of asbestos from flooring materials. To give some idea of the scope of the problem addressed refer to Figure 1, taken from Clifton (1985)[1]. Here we can see that flooring has remained one of the major uses of asbestos ever since the heightened awareness of its risks when we compare thousands of metric tonnes used between 1977 and 1983. Since flooring (when well maintained) is *non-friable* does it constitute a health risk? This third question is beyond the scope of our present investigations.



Year	Flooring	Asbestos cement pipe	Roofing products	Friction products	Coatings and compounds
1977	150	115	70	57	36
1978	138	106	64	53	33
1979	125	96	58	48	30
1980	70	42	24	52	11
1981	67	42	16	52	11
1982	49	38	7	51	13
1983	45	26	6	53	25

Fig. 1. Trend showing the decline of major asbestos uses in the USA during the 1977–83 period. From Clifton (1985). Table gives end-use data in thousands of metric tonnes.

We measured the asbestos content of various samples of asbestos containing floor tiles using organic solvent dissolution of vinyl or asphalt, followed by polarized light microscopy (PLM) and transmission electron microscopy (TEM).

The TEM method gave higher percen-identity by selected area electron diffraction (SAED) and by energy dispersive x-ray analysis (EDAX). We further improved our working method by employing low temperature oxygen plasma ashing of tile samples prior to TEM. Using this last method we arrived at chrysotile asbestos contents ranging from less than 1% to as [illegible]

asbestos. We took several 9" x 9" tiles and attached them to supports. All experiments were carried out in miniature containments of either 1/2 cubic meter (for drilling and breaking experiments) or 1 cubic meter (for stripping experiments). Air monitoring was carried out after the following experiments:

III. Breaking a 9" x 9" tile into 1½" square inch pieces.

IV. Breaking a 9" x 9" tile into four pieces.

V. Applying a blue-green 3M abrasive floor pad for 20s to untreated tile.

VI. Applying a blue-green 3M abrasive floor pad for 20s after treatment with commercial floor finishes.[2]

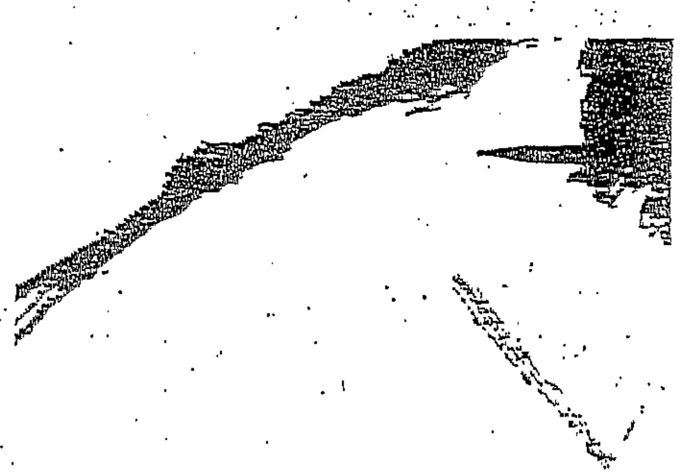
VII. Applying a black 3M abrasive floor pad for 3s after treatment (as in VI).

Air was monitored after each process. In V onwards, the tile was washed with copious water prior to aggressive air sampling. An 18.0 L/minute pump was used for a duration of 30 minutes as longer sampling times made fiber counting difficult due to the large amount of caked vinyl or asphalt. Fiber counting was carried out by phase contrast microscopy (PCM) and the interim TEM protocol described by the EPA. The results of the airborne monitoring are given in Table 2.

It is evident that during such processes as drilling and breaking into many pieces, levels of asbestos fibers released are significantly higher than 0.01 fibers/cm^3 (as tested using Students t-test p less than 0.05). Release after quite vigorous buffing was measurably higher than an acceptable background level, but was not statistically significant. Treatment with commercially available floor compounds appear to lower fiber release. It is interesting to note that although fibers were found on filters from experiment VI and VII (after coating floors) SAED and EDAX proved that at least 80% of the fibers counted were very fine glass.

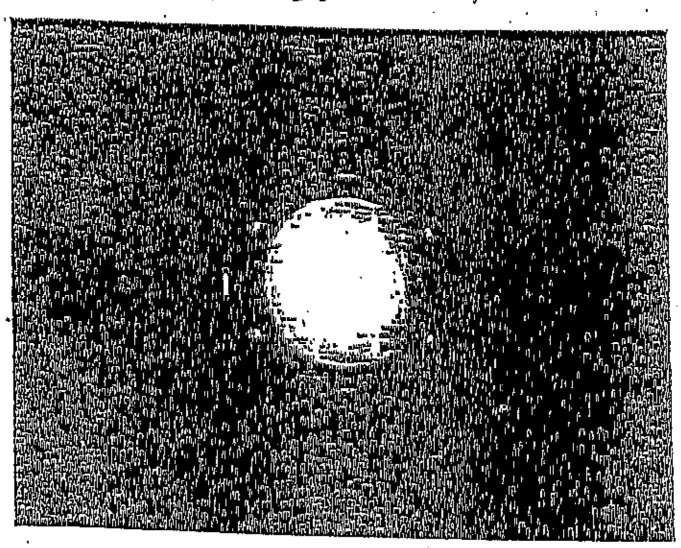
The stripping fluid was sampled (from a constant volume of 300ml) and was found to contain large quantities of chrysotile asbestos fibers when untreated tiles were subjected to abrasion. Figure 2A shows a typical TEM of such a wash. The asbestos content was estimated to be 40% of solids present. After coating with commercially available materials[2] applied exactly according to the manufacturer's instructions, a great reduction in fibers in the stripping fluid was noted, and fiber content was estimated to be less than 1% (Figure 2B). When dealing with fibers associated with vinyl or asphalt coating an invasion of chrysotile fibers occurs, making analysis more difficult. Fibers which extend far beyond the "cakes" of vinyl or asphalt are readily identifiable by ...

2 A Stripping fluid from vinyl-asbestos tile showing vinyl associated as a coating on many hrysotile asbestos fibers. Transmission Electron Micrograph. (Magnification 8,000x).



2 C Fibers of chrysotile asbestos from floor tiles which gave rise to selected area electron diffraction, SAED pattern in 2D. Transmission electron micrograph. (Magnification 20,000x.)

2 B Stripping fluid from polymer coated vinyl-asbestos tile showing very small number of fibers of glass or chrysotile asbestos. Transmission Electron Micrograph (Magnification 2,000x).



2 D SAED of fibers in 2C. The spacing of parallel lines and spots is chrysotile asbestos.

Continued on page 62

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cur during floor maintenance. The asbestos content of stripping fluid is disconcerting since no special disposal has ever been suggested for this material. We are told that many floor maintenance persons buff the uncoated floors at very high speed prior to applying finishes. This generates much dust. Although we have not yet taken samples under these conditions, it would seem more hazardous for workers to treat floors in this way than by using stripping solutions. It is interesting to note that field samples of a floor removal (not assayed by us, but by another NBS, AIHA accredited laboratory) gave airborne fiber levels of 0.026 fibers/cm^3 after carrying our work as modeled in IV. We therefore suggest that our modelling of field conditions is representative, but we are extending our studies to field situations. It seems evident that if a floor containing asbestos is well *maintained*, it offers a minimal asbestos hazard to those near it. The release of fibers during drilling or removal of the floor may represent an acute release problem, but it is impossible to predict a health risk given our present figures. Our study addresses some points associated with the

TABLE 2

Airborne Fiber Content by PCM and TEM††

Experimental Design	Concentration of fibers** in air fibers/cm Mean*	± S.D.
I. Drilling with 1¾ " holes	0.052	0.035
II. Drilling with 1¼ " hole	0.045	0.0067
III. Breaking into 1½ " pieces	0.055	0.032
IV. Breaking into 4 pieces	0.025	0.016
V. Blue 3M pad, untreated tile	0.025	0.012
VI. Blue 3M pad, after treatment[a]	0.011	0.010
VII. Black 3M pad (otherwise as VI)	0.008	0.005

*Triplicate samples each assayed in triplicate.

**NIOSH 7400 A counting rules. Nature of fiber is *not* necessarily asbestos. TEM, SAED, and EDAX were performed on each in triplicate. See discussion.

††TEM method gave results which in most cases paralleled those above, however, were on average 10-20% higher. The S.D. was also greater in each case.

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1. R.A. Clifton, Asbestos in Mineral Facts and Problems, Washington, D.C., U.S.

Asbestos Fibers Release from VA Tile

by: John Jenkins

How much asbestos is released into he air during standard dry removal of vinyl asbestos floor tile? This question has been debated by flooring contractors, asbestos consultants and school building officials for some time. A recent test conducted by the DeKalb County, Georgia School System produced interesting results. Floor covering replacement for a 15-year old elementary school was scheduled and offered an excellent opportunity to investigate the release of asbestos fibers during the process of removing old vinyl asbestos tile. A classroom in the school was selected as a test ar[illegible] and a flooring contractor was a[illegible]ized to remove the old floor an[illegible]stall a new Type IV Vinyl Comp[illegible]n floor covering in the room [illegible] standard floor removal and re[illegible]ment procedures.

Prior to beginning the removal, a test procedure was developed for determining fiber release[1]. The procedure called for pre-removal and post-removal monitoring using both phase contrast procedures and transmission electron microscopy procedures[2]. Samples were to be taken at a flow rate of 16 liters per minute and at a total volume of 2,400 liters. Filters for phase contrast analysis were standard Millipore filters while those for electron microscopy were Nuclepore. All filters were 37 mm diameter filters. All sampling was done using aggressive techniques.

Pre-removal sampling in the room produced a level of 0.01 fibers/cc using phase contrast test (P&CM 239) and [illegible] asbestos fibers were detected in the [illegible] test. Since no asbestos fibers were [illegible] in the classroom, no outside [illegible] air test was conducted. The [illegible] 12" x 1/8" floor tile was then [illegible]ed using spud hoes and an electrical [illegible]

showed a fiber level of 0.08 fibers/cc. The TEM test showed a level of .0838 fibers/cc with a weight of 0.5695 nanograms per cubic meter. Analysis of the fiber size showed that all fibers were less than 5 microns in length and that 60% of the fibers were approximately .05 microns in diameter with approximately 40% being 0.1 microns in diameter. All asbestos fibers were chrysotile.

The classroom was closed off to permit settling in the room and then cleaned to remove residual fibers. TEM testing confirmed that the room was clean.

A sample of the removed tile was subjected to analysis by optical microscope using polarized light and dispersion staining techniques. This analysis indicated an asbestos content of less than 1%. This percentage was not consistent with the tile manufacturer's reported mixtures and not consistent with the post-removal fiber count. The manufacturers report that mixtures normally contain ten to fifteen percent chrysotile asbestos. A recheck of the sample using an optical microscope and polarized light did not confirm the reported content so additional procedures were used for testing the bulk sample. A portion of the same was crushed to a powder and dispersed in distilled water[3]. The large particles were allowed to settle and a drop of the suspension was placed on a TEM grid and dried. Analysis of this grid verified that the tile probably contained at least 10% asbestos, which is consistent with the manufacturer's statements and also supports the measured levels in the air after removal.

The DeKalb County School System is aware that air monitoring is not an exact science and for this reason determined to repeat the test on a second classroom in the same school. The procedures utilized in the second test were the same as those employed for the first test. The pre-removal test confirmed that no asbestos fibers were present and therefore no outside ambient test was conducted.

Floor tile removal procedures were the same as those used in the first test. It was noted that during this removal the classroom windows were open and that the classroom door to the corridor was also open. The phase contrast reading for the post-removal air monitoring was 0.009 fibers/cc. The TEM reading was .2384 fibers/cc with a mass of 26109.3 nanograms per cubic meter. The micrograph below illustrates the wide dispersion of fiber sizes in the sample analyzed by TEM methods.

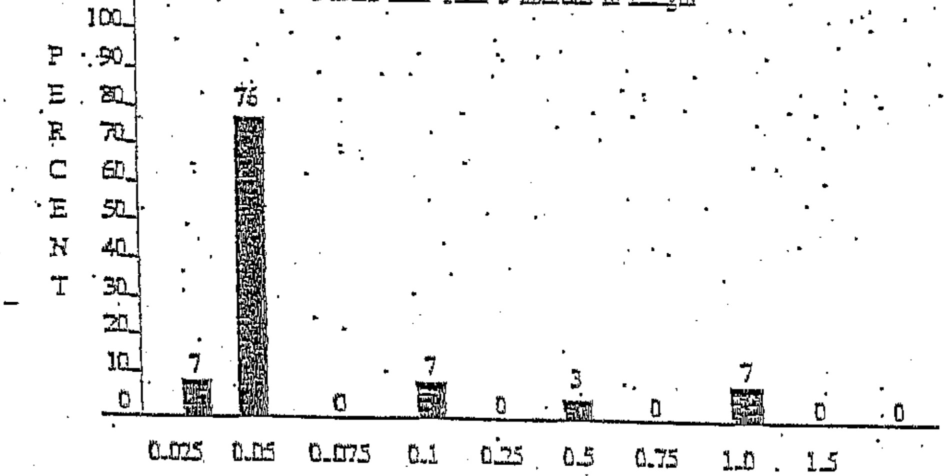
CONDENSED DATA

1.	Number of Asbestos Fibers analyzed	40
2.	Number of Nonasbestos Fibers analyzed	50
3.	Number of Ambiguous Fibers analyzed	0
4.	Asbestos type	Chrysotile
5.	Concentration of Asbestos Fibers (fibers/cc) or (million/m³)	0.2382
6.	Percentage of concentration due to Asbestos Fibers ≥5 um (microns) in length	

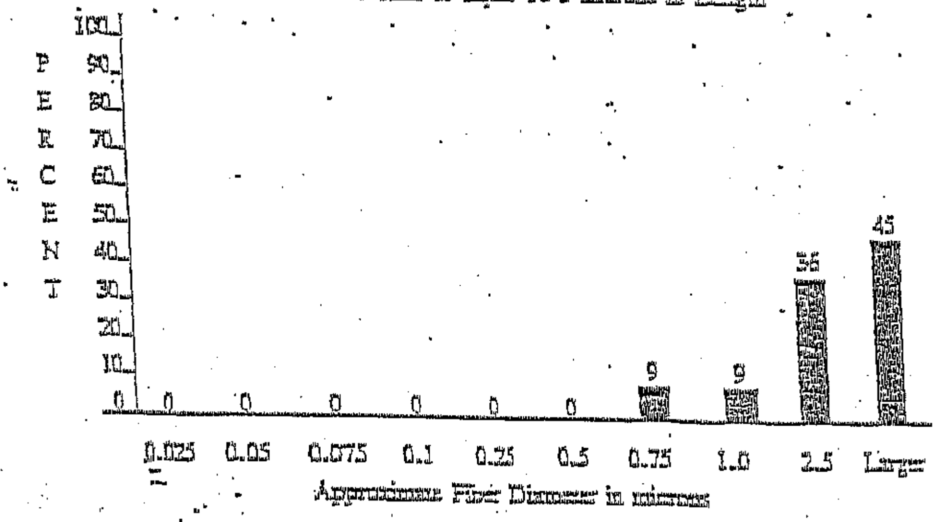
CONTINUATION OF ASBESTOS RELEASE FROM VA TILE

CHRYSOTILE

Fibers Less Than 5 microns in Length



Fibers Greater Than or Equal To 5 microns in Length



Because of the air circulation from the classroom to the corridor during the second removal, a decision was made to test the air in the corridor outside of the classroom. This test using TEM procedures indicated a fiber count of 0.0558 fibers/cc of chrysotile asbestos. The mass of the fibers in this sample was only 0.0854 nanograms per cubic meter. All of the fibers collected in this sample were less than 5 microns in length with 50 percent of the fibers having a diameter of 0.025 microns and the remaining 50 percent having a diameter of 0.5 microns. No phase contrast test was conducted in this area.

Both the classroom and the administration tests were not fully laboratory controlled tests, but are certainly indicative of the problems relating to tile removal. The following conclusions were reached based on the results of the test:

1. A significant amount of asbestos fiber is released during removal of vinyl asbestos tile using conventional tile removal methods.
2. Fiber control methods such as damp removal or isolation of areas by plasticizing and use of appropriate respirators should be used for tile removal.
3. Areas subjected to contamination by tile removal using uncontrolled methods should be

ical method of removing tile safely. Investigations will probably be conducted on damp removal methods and area isolation and cleaning procedures.

[1] Test procedures developed by Southern Engineering Company. Sampling performed by Southern Company, 1800 Peachtree Street, N.W., Atlanta, Georgia 30367-8301. John M. Jenkins, Vice President.

[2] Laboratory testing by Electron-Microscopy Services Laboratories, Inc., 108 Baden Avenue, Westmont, New Jersey 08108. Dr. Peter Frasca, Ph.D., Director

[3] Sample test procedure by Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, Georgia 30332. James L. Hubbard, Senior Scientist.

John M. Jenkins