AN EVALUATION OF ASBESTOS EXPOSURES IN OCCUPIED SPACES

FEBRUARY, 2005

A REPORT BY

THE CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING

FOR

THE CONNECTICUT DEPARTMENT OF PUBLIC HEALTH

Connecticut Academy of Science and Engineering

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An Evaluation of Asbestos Exposures in Occupied Spaces

A Report By

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Origin of Inquiry:	Connecticut Department of Public Health
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This study was initiated at the request of the Connecticut Department of Public Health on August 6, 2004. The study was conducted by an Academy Study Committee with the support of David Pines, Study Manager. The content of this report lies within the province of the Academy's Environment and Public Health Technical Boards. The report has been reviewed by Academy Members Gale F. Hoffnagle and Jan A. J. Stolwijk. Ms. Martha Sherman, the Academy's Managing Editor, edited the report. The report is hereby released with the approval of the Academy Council.

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EXECUTIVE SUMMARY

STUDY OBJECTIVES

The Connecticut Department of Public of Health (DPH) administers regulations related to the management of asbestos in public and non-public elementary and secondary schools. These regulations parallel regulations promulgated by the US Environmental Protection Agency (EPA) under the Asbestos Hazard Emergency Response Act (AHERA). Each school is required to have a licensed professional (defined as a licensed asbestos professional who has been approved by DPH for developing asbestos management plans and performing site inspections) perform an initial inspection for the presence of asbestos and to develop an asbestos management plan that is maintained and updated. Additionally, a reinspection by a licensed professional is required every three years. Based upon these inspections, the local education agency (LEA) must select and implement an appropriate response action designed to protect human health and the environment consistent with regulatory requirements.

In the Brookfield Public Schools and Amity School District, parents were concerned about the effectiveness of their school's asbestos management plan. To address this concern, micro-vacuum dust sampling was conducted to determine if asbestos was present in the settled dust. However, there is currently no regulatory or universally recognized standard for implementing a response action based upon the asbestos level in settled dust.

The Connecticut Academy of Science and Engineering (CASE) was requested by DPH to perform a study to provide guidance on issues that may arise during the current (2004-2005) school year regarding asbestos contamination in schools. The primary goal of this study was to develop interim suggested guidelines that should be followed concerning asbestos contamination in schools, including the use of asbestos in dust data. This was accomplished by convening a study committee that included locally and nationally recognized asbestos health scientists. The committee was briefed on issues specific to Connecticut by a project planning team convened by DPH, discussed and deliberated on methods and protocols for evaluating asbestos contamination in schools, and developed suggested guidelines for the assessment of asbestos contamination in schools. The Study Committee's investigation and development of suggested guidelines and findings were based on its knowledge of current known science regarding the topic and, at the request of DPH, were not confined to regulatory requirements as expressed in existing federal and state laws.

SUGGESTED GUIDELINES

Through a series of meetings, teleconferences, and emails, the study committee developed a four-step plan for assessment of asbestos-containing material (ACM) in schools to address concerns regarding asbestos contamination, as follows:

Step 1 – Inventory and Record Keeping Review of Asbestos Containing Materials (ACM);
Step 2 – Seek Professional Advice;
Step 3a – Surface Dust Sampling in High Contact Areas;
Step 3b – Airborne Sampling and Determination of Asbestos Fiber Contamination;
Step 4a –Remediation of Location;
Step 4b – Cleanup and Abatement of Asbestos.

SUMMARY OF FINDINGS

In summary, the committee would like to emphasize the following points concerning asbestos contamination in schools:

- Following good management practices as outlined in the AHERA regulations, including maintaining the school's Asbestos Management Plan, a current inventory list, and good records, is a critical step in achieving a safe indoor environment.

- Providing flexibility for a licensed professional to efficiently implement an appropriate response plan which may include dust and/or air sampling, or immediate contamination abatement, is important.

- If microvacuum dust sampling is used to collect surface dust, samples should be collected in high contact areas (see Step 3a on page 4 of the report for additional information) immediately prior to the next janitorial cleaning to determine the probability of airborne asbestos. Currently there are insufficient data to specify a threshold level for intervention. Because of the potential of this technique to characterize the level of asbestos contamination, it is recommended that additional studies be conducted to determine whether or not it is possible to establish a statistically significant threshold value for long fibers of asbestos in settled dust.

- Assessing the health risk of asbestos fiber contamination is accomplished by activity-based airborne sampling.

- Counting long fibers that are greater than 5μm in length, which are most likely associated with increased risk of lung cancer and mesothelioma, should be the standard analytical procedure, as opposed to counting all asbestos structures.

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I. INTRODUCTION

The Connecticut Department of Public of Health (DPH) administers regulations related to the management of asbestos in public and non-public elementary and secondary schools. These regulations parallel regulations promulgated by the US Environmental Protection Agency (EPA) under the Asbestos Hazard Emergency Response Act (AHERA). Each school is required to have a licensed professional (defined as a licensed asbestos professional who has been approved by DPH for developing asbestos management plans and performing site inspections) perform an initial inspection for the presence of asbestos and to develop an asbestos management plan that is maintained and updated. Additionally, a reinspection by a licensed professional is required every three years. Based upon this assessment, the local education agency (LEA) must select and implement an appropriate response action designed to protect human health and the environment consistent with regulatory requirements.

In the Brookfield Public Schools and Amity School District, parents were concerned about the effectiveness of their school's asbestos management plan. To address this concern, micro-vacuum dust sampling was conducted to determine if asbestos was present in the settled dust. However, there is currently no regulatory or universally recognized standard for implementing a response action based upon the asbestos level in the settled dust.

The Connecticut Academy of Science and Engineering (CASE) was requested by DPH to perform a study to provide guidance on issues that may arise during the current (2004-2005) school year regarding asbestos contamination in schools. The primary goal of this study was to develop interim suggested guidelines that should be followed concerning asbestos contamination in schools, including the use of asbestos in dust data. This was accomplished by convening a study committee that included locally and nationally recognized asbestos health scientists that:

- Was briefed on issues specific to Connecticut by a project planning team convened by DPH;
- Discussed and deliberated on methods and protocols for evaluating asbestos contamination in schools; and
- Developed suggested guidelines for the assessment of asbestos contamination in schools.

The Study Committee's investigation and development of suggested guidelines and findings were based on its knowledge of current known science regarding the topic and, at the request of DPH, were not confined to regulatory requirements as expressed in existing federal and state laws.

II. SUGGESTED GUIDELINES

Through a series of meetings, teleconferences, and emails, the study committee developed a four-step plan for assessment of asbestos-containing material (ACM) in schools to address concerns regarding asbestos contamination. A flow chart that articulates this plan is shown in Figure 1 and a summary of the committee meeting minutes is provided in Appendix A. The following sections of this report discuss each step of the suggested guidelines.

Step 1 – Inventory and Record Keeping Review of Asbestos Containing Materials

Good management practice as outlined by the AHERA regulations is a very important and cost effective method for maintaining a safe indoor environment for students, teachers, and staff. In Connecticut, DPH is responsible for ensuring compliance with AHERA regulations. This includes maintaining and updating the asbestos management plan, verifying that the asbestos inventory list is current and accurate, reviewing cleaning procedures, keeping accurate documentation of repair and maintenance records, and inspecting ACM. To assist the schools in knowing the latest information on asbestos contamination, DPH should educate school systems on best management practices and provide an up-to-date list of ACM.

For those schools where visual inspection of ACM does not show any friable material, and good documentation and management practices exist, no further action is required. If this is not the case, the school must implement an appropriate response action designed to protect human health and the environment as outlined in Steps 2, 3, and 4. These actions should ensure compliance with AHERA regulations and the corresponding regulations of Connecticut state agencies, including maintaining an accurate and updated asbestos management plan for each school facility. The need to proceed to Steps 2, 3, or 4 because of poor documentation should be minimized because of the potential unnecessary expense of dust/air sampling and remediation. To stress the importance of good documentation and management plans, DPH should consider providing an incentive to school districts that meet this requirement.

Step 2 – Seek Professional Advice

Depending on the findings in Step 1, it may be necessary to perform dust sampling to determine the presence and type of asbestos on surfaces as outlined in Step 3a or air sampling to perform a risk assessment of the location as outlined in Step 3b. In some situations, the asbestos contamination may be considered severe enough that removal or containment of the material is deemed necessary (see Step 4a). In order to make the determination of whether to proceed to Step 3a, 3b, or 4a, the LEA needs to seek the advice of a licensed professional who is approved by DPH for developing asbestos management plans and performing site inspections. The licensed professional should perform a visual inspection of the ACM, review the school's documentation, and possibly collect bulk samples. Instead of imposing a specific sampling sequence, the flexibility provided in this step allows the professional to make the appropriate response to quickly address the problem, including updating the school's asbestos management plan as may be required.

Step 3a – Surface Dust Sampling in High Contact Areas

If professional advice (see Step 2) indicates that surface dust sampling should be utilized as an exposure assessment tool, then the sampling technique chosen should be the microvacuum dust sampling procedure as specified by the American Society for Testing and Materials (ASTM) in ASTM D5755. This technique should be regarded as a measurement tool for determining the presence and type of asbestos on surfaces. Such sampling should most optimally take place immediately prior to the next janitorial cleaning. A minimum of three samples per location should be taken from high contact areas, which are locations where children, teachers, and non-maintenance staff can generally reach, disrupt and suspend surface dust into the air. Background samples should also be collected in locations where there are no known ACM. These background samples are taken to provide reference values which can be compared to samples taken from the area(s) of concern, as well as to identify if a school's background values are lower than established/accepted background levels. The samples should be analyzed by way of Transmission Electron Microscopy (TEM) using 5000X magnification to identify asbestos fibers of greater than 0.1μm in width. Asbestos fibers greater than 5μm in length should be counted, and the resulting number should be reported as numbers of long fibers (LF) per cm^2 of surface area tested. The specific long fiber counting criteria and methodology are outlined in Appendix B.

If any of the three samples from a location in question is found to contain amounts exceeding a still to be determined (TBD) LF/cm^2 threshold, then Step 3b should be initiated. If none of the three samples from a location in question exceeds the TBD threshold, and if there is no visual evidence of degradation of ACM, then the licensed professional should determine if any measures such as cleaning are necessary. If none of the three samples from a location in question exceeds the TBD LF/cm^2 threshold, but there is visual evidence of degradation of ACM, then a school may choose from one of three options: (1) Encapsulate the degraded ACM; (2) Remove the degraded ACM; or (3) Perform routine follow-up measurements of air levels.

Several explanatory notes regarding both dimensions of asbestos fibers and threshold values are in order here. First, the specific recommendation to count only fibers greater than 5μm in length was based on the study committee's consensus that such a length threshold is currently well supported in the literature. The primary physiologic basis for this specification is the ability of alveolar macrophages to phagocytose and subsequently clear shorter asbestos fibers from the airways. The longer the fiber, the lower the probability that a macrophage will successfully ingest and clear the fiber from the air passages. There are multiple references available to support this correlation between fiber length and pathogenicity as well as the corresponding use of 5μm as a length threshold. In 1988, Dr. Morton Lippmann, Professor of Environmental Medicine, New York University, published a review of data from experimental animal studies exposed by inhalation and injection to fibers of varying sizes in which he concluded that mesothelioma and lung cancer are most closely associated with numbers of fibers greater than ~5μm and ~10μm respectively. Lippmann reached similar conclusions that supported a 5μm cut-off size by way of regression analysis in 1994. Lending further support to such a cut-off, a 2003 Eastern Research Group report, prepared for the Agency for Toxic Substances and Disease Registry (ATSDR) and entitled *Report on the Expert Panel on Health Effects of Asbestos and Synthetic Vitreous Fibers: The Influence of Fiber Length*, stated, "Many of the short fibers that reach the gas exchange region of the lung are cleared by alveolar macrophages, and the rate of clearance by phagocytosis has been found to vary with fiber length…there is a strong weight of evidence that asbestos and SVFs (synthetic vitreous fibers) shorter than 5μm are unlikely to cause cancer in humans." Similarly, another 2003 report prepared by the Eastern Research Group for the EPA, stated that there was agreement among the panelists convened that "the available data suggest that the risk for fibers less than 5μm in length is very low and could be zero." Lending yet further support to the use of a 5μm length threshold, the HEI-AR (Health Effects Institute – Asbestos Research) 1991 report, entitled *Asbestos in Public and Commercial Buildings: A Literature Review and Synthesis of Current Knowledge*, quite clearly states in its section on fiber length:

> While the differential responses to fibers of different lengths cannot yet be specified precisely, the data suggest that the risks of lung cancer and mesothelioma increase with increasing fiber length. In particular, a substantial body of experimental evidence suggests that the rates of induction of tumors and fibrosis in animals, as well as transformation of cells in vitro, increase sharply as fiber length increases above 5μm. Thus, the conventional definition of an asbestos fiber used for industrial hygiene purposes (fibers longer than 5μm with an aspect ratio of 3 and greater) continues to be a practical index for risk assessment; the use of this index also facilitates comparison of present observations with those in the earlier literature. Whether there is any length threshold below which there is no carcinogenic effect in humans is not known. Animal data suggest, however, that very short fibers have much less carcinogenic activity than longer fibers and may even be relatively inactive.

In summary, for all of the reasons cited above, the committee asserts that both this study and any future studies of microvacuum dust sampling should focus on fibers longer than 5μm.

With regard to fiber dimension, the committee's rationale for including only those fibers with a width greater than 0.1μm in the analysis relates to the generally accepted fact that this approximate width is considered to be the practical limit of what an analyst can clearly see at 5000X magnification. As such, the exclusion of narrower fibers allows for appropriate standardization of the counting technique across various laboratory technicians. The committee agreed that any attempt to include fibers narrower than 0.1μm in the analysis would significantly jeopardize such standardization, ultimately resulting in the inability to make any meaningful comparisons between two or more samples.

The committee's decision to exclude specific microvacuum dust threshold values from Phase 1 of this project also merits further discussion. Over the course of the multiple conferences held by the committee to examine Phase 1 objectives, substantial efforts were made to derive such a threshold value in terms of LF/cm^2 of sample surface. Surface Dust Decision Values have generally been determined by either a comparison to a "background" value or by attempting to relate the surface dust loading to an air level using a resuspension model. The committee discussed using both approaches to derive a threshold value for LF/cm^2 of dust in Connecticut schools. Using the "background" approach, the committee discussed modifying a cleanup benchmark (derived from data collected in homes contaminated with World Trade Center dust) with the average short-to-long fiber ratio for asbestos in dust from data collected in two Connecticut schools. Using the "resuspension" approach, the committee discussed dividing one report's average value for asbestos in school buildings' air by a resuspension factor (a "K" factor). While the committee agrees that the methodologies behind such calculations represent promising models, they also recognize that there are several obstacles that preclude making any recommendations about LF/cm^2 thresholds at this time:

1. The dust benchmarks and K factors that are currently in use do not yet enjoy the scientific justification that is needed to fully validate their utilization.

2. The experience-based ratio of short-to-long fibers is based on rather limited data from two Connecticut school districts, thus posing a significant threat to the ratio's validity and reliability for ACMs having other fiber size distributions.

Put another way, surface dust benchmarks, K factors, and experience-based ratios are not as yet health-based. This is not to say, however, that the committee believes that the pursuit of such health-based indicators is futile. In particular, the committee is in agreement that what is specifically needed are better data in order to make a reasonable determination of acceptable risk levels. As such, the committee proposes a multi-pronged study that deserves consideration in Phase 2 of this project. This study would include: 1) Dust and air sampling in Connecticut schools known not to have an asbestos contamination problem in order to obtain accurate background levels (with samples collected and analyzed as per the procedures set forth in Steps 3a and 3b); 2) Research on the serpentine content of rock formations in Connecticut; 3) Outdoor (e.g., soil) sampling for asbestos as a means by which to examine the issue of possible outdoor sources. While the committee is not yet in a position to recommend a long fiber threshold for dust samples, the development of such a threshold can be revisited after the data in Phase 2 are collected.

Step 3b – Airborne Sampling and Determination of Asbestos Fiber Contamination

If advice from a licensed professional (see Step 2) indicates that airborne sampling should be utilized as an exposure assessment tool, or if surface dust sampling (see Step 3a) produces a sample exceeding the TBD threshold, then activity-based monitoring should be employed. Activity-based monitoring should be conducted during a school's normal period of operation, during the normal operation of the air handling and mechanical equipment and during normal levels of maintenance and custodial activities. Specifically, an area sampler should be used to periodically monitor air in the classroom(s) of concern over a period of time that reflects a typical length of occupancy for students within the particular classroom(s). For example, if students typically occupy a given classroom for six hours per day, air sampling should occur over a six-hour period. A minimum of three air samples should be collected from each area and the asbestos concentration calculated using the accumulated air sample. The recommendation for a minimum of three air samples from the same area is based on the procedure used by EPA for residences affected by the collapse of the World Trade Center. The collection of more samples is preferred because it increases the analytical sensitivity of the test. If the samples are too loaded at 3000 liters for proper analysis, more samples need to be collected and/or more analytical effort can be used to achieve the same result. For example, the AHERA protocol for clearance of an abatement project requires that five samples be collected. In addition, area sampler(s) should also be utilized in order to periodically monitor the same area(s) of concern during custodial cleaning activities such as sweeping or vacuuming. Personal samplers should be utilized to monitor the custodial staff's exposures during normal building maintenance. The samples should then be analyzed by way of phase contrast microscopy equivalent (PCME).

The corrective action to be taken depends on whether the sample from an area of concern exceeds 0.0005 LF/cm^3, whether the area has damaged friable ACM, or whether dust sampling initiated airborne sampling. If the sample from the area of concern exceeds 0.0005 LF / cm^3, then Step 4a (Remediation of Location) should be initiated. If the sample from an area contains less than 0.0005 LF/cm^3, one of three response actions is suggested: (1) If the area has damaged friable ACM, then the guidelines in Step 4b (Cleanup and Abatement of Asbestos) should be followed; (2) If the area has long fiber asbestos in the surface dust > TBD threshold but no damaged friable ACM, the first three parts of Step 4b should be followed. These include cleaning the location per the school's Operation and Maintenance Program under the Asbestos Management Plan, periodic testing to verify location does not have airborne asbestos long fiber concentration greater than 0.0005 LF/cm^3, and determining the source of the long asbestos fibers; (3) If Step 3b was initiated because of the licensed professional's recommendation to do airborne testing (i.e., bypass dust sampling step to utilize airborne testing as an exposure assessment tool) and the area does not have damaged friable ACM, then no further action is required.

The 0.0005 LF/cm^3 threshold value was selected because it is a health-based value with as good a risk estimate as can be determined with present data. This threshold value cannot be compared directly to the AHERA clearance criteria of 70 s/mm^2, which is based on the background value of asbestos structures on blank filters. More details about the difference between these two measurement techniques can be found in Appendix C. Further support for this threshold value for airborne sampling can be found in the 1991 HEI-AR report in which the institute notes:

> "average levels in schools that have been surveyed herein are higher than those in other buildings, approximating 0.0005 f/mL, for which the corresponding predicted lifetime risk to a child exposed during school hours would be about 6 (premature cancer deaths) per million. These risk estimates, although highly uncertain for the reasons indicated, can be used to compare the public health hazard posed by different levels of indoor asbestos with the risks of other environmental agents for which control strategies may also be under consideration…"

The selection of the 0.0005 LF/cm^3 threshold, is also based, in part, upon practical considerations in terms of measurement feasibility. It also should be noted that the designation of long fibers for air samples is different than that for dust samples. The "LF" designation for the air samples refers to PCME fibers that are longer than 5 μm and wider than 0.25 μm, while the "LF" designation for dust samples refers to TEM using 5000x magnification which are fibers longer than 5 μm and wider than 0.1 μm.

Step 4a –Remediation of Location

If any of the samples from an area of concern sampled in Step 3b exceed 0.0005 LF/cm^3, or if a licensed professional (see Step 2) otherwise deems such intervention necessary, then remediation of the location(s) of concern should take place. The area(s) in question should be closed off, and access should be limited to licensed asbestos abatement contractors. Significant attempts must be made to determine the source(s) of any long asbestos fibers that have been found in dust and/or airborne samples. Possible sources/triggering events which merit investigation in such a situation include friable ACM, air ducts, cleaning and/or maintenance work involving asbestos-containing tile, and any other repair or maintenance work that might have disturbed ACM. It is incumbent upon the school to assure that such an investigation of source takes place. This is also the reason why inventory and record-keeping in strict compliance with current AHERA regulations is essential; such records may facilitate the successful investigation and determination of point source(s). In the event that the probable origin of long asbestos fibers cannot be determined by way of the recommendations above, and only after the potential sources cited above have been examined, a forensic analysis of dust samples should be employed. Once the most likely source has been identified, the location should be cleaned and ACM should be either removed or encapsulated per the abatement procedures typically employed by the licensed professionals involved in said investigation. Prior to re-opening the area, verification that the asbestos remediation has been done properly as per current AHERA abatement regulation procedures must occur. Subsequent to such intervention, the area should be monitored by way of air sampling after a reasonable period of time has elapsed, such as 1-3 months, to verify that harmful levels of airborne asbestos fibers are not present.

Step 4b – Cleanup and Abatement of Asbestos

If none of the samples from the area(s) of concern sampled in Step 3b exceed 0.0005 LF/cm^3, or if a licensed professional (see Step 2) otherwise deems such intervention necessary, then the area(s) of concern should be cleaned as per the school's Operation and Maintenance Program under the Asbestos Management Plan (see Step 1). After such cleaning has taken place, periodic testing should take place to reaffirm that the location in question does not have an airborne asbestos long fiber concentration in excess of 0.0005 LF/cm^3. Such testing should take place after a reasonable period of time has elapsed, such as 1-3 months. Significant attempts to discover the source(s) of any long asbestos fibers found in dust samples should be made as per the recommendations in Step 4a. Any and all ACM that is found should be either removed or encapsulated per abatement procedures typically employed by the licensed professionals involved in said investigation. Such encapsulation or removal should take place over summer vacation or over some other extended vacation period. Prior to re-opening the area, verification that the asbestos remediation has been done properly as per current AHERA abatement regulation procedures must occur.

III. SUMMARY OF FINDINGS

In summary, the committee would like to emphasize the following points concerning asbestos contamination in schools:

- Following good management practices as outlined in the AHERA regulations regarding the maintaining and updating of a school's Asbestos Management Plan, keeping a current inventory list, and having good records are critical steps to achieving a safe indoor environment for students, teachers, and staff.

- Providing flexibility for a licensed professional to efficiently implement an appropriate response plan, which may include dust and/or air sampling, or immediate abatement of the contaminated area, is important.

- If a microvacuum dust sampling is used to collect surface dust, samples should be collected in high contact areas immediately prior to the next janitorial cleaning. At this time, there are insufficient data available to specify a threshold level for intervention. Because of the potential of this technique to characterize the level of asbestos contamination, it is recommended that additional studies be conducted to determine whether or not it is possible to establish a statistically significant threshold value for long fibers of asbestos in settled dust.

- Assessing the health risk of asbestos fiber contamination is accomplished by activity-based airborne sampling.

- Counting fibers that are greater than 5μm in length, which are most likely associated with increased risk of lung cancer and mesothelioma, should be the standard analytical procedure as opposed to counting all asbestos structures.

Figure 1: Suggested Guidelines for 3-Year Reassessment of Asbestos Containing Material and Parent/Teacher Concern about Exposures to Asbestos in Schools

Step 1 – Inventory and Record Keeping Review of ACM

- Determine if the Asbestos Management Plan is in compliance per AHERA
- Identify new materials that contain asbestos that had not been documented in Management Plan
- Visual inspection of ACM
- Review cleaning procedures in the School's Operation and Maintenance Program
- Review repair/maintenance records documenting procedure followed when ACM was disturbed
- Update Asbestos Management Plan
- Education – periodic update provided to school systems on best management practices and potential sources of asbestos fibers by DPH
- Determine potential sources of asbestos contamination based upon review of records and visual inspection

Response plan for protecting human health and the environment if visual inspection and/or record keeping indicate potential of asbestos contamination.

Visual inspection shows no friable material and documentation indicates inventory, cleaning procedures (e.g., buffing of asbestos containing tile), and repair/maintenance records are in order.

- No further action required
- Incentive for good documentation and management plan

Step 2- Seek Professional[1] Advice

Seek professional advice about remediation/exposure assessment options from a licensed professional. After a careful visual assessment, a records review and possibly the collection of additional bulk samples, the professional may recommend additional exposure assessment (surface dust and/or air sampling). Alternatively, the professional may recommend removal or containment of ACM. If the professional recommends surface dust sampling, the procedure in the surface dust sampling section should be followed (3a). If the professional recommends air sampling, the procedure in the air sampling section should be followed (3b). At any time throughout their survey, the professional may recommend removal, containment, or general cleanup. In this case the procedure in the remediation section should be followed (4).

[1]A professional is defined as a licensed asbestos professional who has been approved by DPH for developing asbestos management plans and performing site inspections

Step 3a - Surface Dust Sampling in High Contact Areas

- Surface dust sampling is used as a measurement tool for determining the presence and type of asbestos on surfaces
- Sampling Technique – Microvacuum dust sampling procedure as specified in ASTM D5755
- Sampling Locations
  - High contact areas[2] that are in close proximity to ACM
  - Background samples collected in locations where there is no ACM
  - Minimum of three samples collected per location
- Sample should be collected immediately prior to the next janitorial cleaning.
- Sample Analysis
  - TEM using 5000x magnification with asbestos fiber identification and detection of fibers of greater than 0.1μm width (Draft Method D5755-02)
  - Count asbestos fibers (not structures) greater than 5μm in length
  - Specify length and width of each fiber greater than 5μm in length
  - Report as number of long fibers per cm^2 surface area tested
  - Laboratory certification criteria to be determined by DPH
- Statistical Analysis of Data
  - Maximum long fiber surface concentration for each location should be used for determining if airborne testing is required

Long Fibers/cm^2 > TBD[3]

Go to Step 3b

Long Fibers/cm^2 < TBD[3]

- If there is degradation of ACM, encapsulate or remove degraded surfaces as a precaution, or make routine follow-up measurements of air levels
- If no visual degradation of ACM, professional will decide if cleaning or other measures are necessary

[2]High contact areas are defined as locations that children, teachers, and non-maintenance staff can generally reach, disrupt and suspend surface dust into the air. It may be necessary to collect samples from high dust accumulation, low contact areas for determining source of asbestos contamination, but these samples should not be used to determine if air sampling is required.
[3]Long fiber background data from dust samples collected in schools that have no ACM are needed before a dust sampling threshold value can be established. The samples need to be collected and analyzed as specified in Step 3a.

Step 3b – Airborne Sampling & Determination of Asbestos Fiber Contamination

- Airborne Sampling is used for risk assessment of locations where it is expected that there is asbestos contamination

- Activity-based monitoring
  - Use area sampler to periodically monitor air in classroom during normal teacher/student activities
  - Use area sampler to periodically monitor air during custodial cleaning activities (e.g., sweeping and/or vacuuming)
  - Conduct personal sampling on custodians during normal building maintenance
  - A minimum of 3 samples should be collected from each area with the accumulated air sample used to calculate the asbestos concentration

Long Fibers / cm^3 > 0.0005 → Go to Step 4a

Long Fibers / cm^3 < 0.0005 and area has damaged friable ACM → Go to Step 4b

Long Fibers / cm^3 < 0.0005 and surface dust > TBD LF/cm^2 and area has no damaged friable ACM → Perform first three parts of Step 4b (clean, periodic testing, and determine source of long fibers)

Long Fibers / cm^3 < 0.0005 and no dust data (i.e., professional went directly to airborne testing) and area has no damaged friable ACM → No further action is required

Step 4a –Remediation of Location

- Close off contaminated locations and limit access to licensed asbestos abatement contractors
- Determine source of long asbestos fibers
  - Investigate how ACM was transported to locations where high levels of long asbestos fibers were found in the surface dust samples and airborne samples
    - From friable ACM
    - From cleaning/maintenance of asbestos containing tile
    - Via air ducts
    - From repair/maintenance or other incidents that could have disturbed the ACM
  - As last resort, do forensic analysis of dust sample to determine probable origin of asbestos fibers
- Clean location and remove/encapsulate ACM per abatement regulations procedure
- Verify that the asbestos remediation has been done properly as per current AHERA abatement regulation prior to re-opening the area
- Subsequent monitoring to verify location does not have harmful level of airborne asbestos fibers as per current AHERA abatement regulation procedures

Step 4b – Cleanup and Abatement of Asbestos

- Clean location per school's Operation and Maintenance Program under the Asbestos Management Plan
- Periodic testing to verify location does not have airborne asbestos long fiber concentration of greater than 0.0005 LF/cm^3
- Determine source of long asbestos fibers
  - Investigate how ACM was transported to locations where high levels of long asbestos fibers were found in the surface dust samples and airborne samples
    - From friable ACM
    - From cleaning/maintenance of asbestos containing tile
    - Via air ducts
    - From repair/maintenance or other incidents that could have disturbed the asbestos containing material
  - As last resort, do forensic analysis of dust sample to determine probable origin of asbestos fibers
- Remove/encapsulate ACM per abatement regulations procedure during summer break or extended vacation periods
- Verify that the asbestos remediation has been done properly as per current AHERA abatement regulation prior to re-opening the area
- Subsequent monitoring to verify location does not have harmful level of airborne asbestos fibers as per current AHERA abatement regulation procedures

APPENDIX A:
SYNOPSIS OF COMMITTEE MEETING MINUTES

CASE Study Committee Minutes
An Evaluation of Asbestos Exposures in Occupied Spaces
Friday, October 1, 2004

Study Committee Members in attendance: Anne Bracker, Mark Cullen, Morton Lippmann, John Morris, James Millette, David Pines, Gary Ritter, Eileen Storey, John Vasselli, Matthew Willis; Academy Staff: Rick Strauss
Connecticut Department of Public Health (DPH) Project Planning Team Members in attendance: Laura Anastasio, Ellen Blaschinski, Jackie Brown, Lorri Cavaliere, Dick Edmonds, Karen Flanagan, Savita Trivedi, Ron Skomro, Brian Toal, Karla Turekian

1) Introductory comments were provided by CASE. The two phases of the project were described. Phase 1, which is the phase that is now being undertaken by the Study Committee, involves the development of interim guidelines for schools that address asbestos remediation in the absence of an asbestos abatement project. This will include a review of measurement techniques in dust and air for evaluation of asbestos related health risk in schools and in response to reported findings of asbestos contamination in schools. Phase 2, which is expected to be more lengthy, will involve asbestos contamination in Connecticut public schools as a more general issue, and is expected to take up to one year to complete, depending on final project scope. Study Committee and Project Planning Team members introduced themselves. The DPH framed the issues which they wished to see addressed by the Study Committee. The Department has found it very difficult to determine how best to respond to recent incidents involving the acquisition and presentation of microvacuum dust sampling data by private parties in the Brookfield and Amity school districts. DPH feels that an appropriate response cannot be determined at this time due to the lack of knowledge about the utility of data regarding asbestos in settled dust. Hence, the services of the Connecticut Academy of Science and Engineering and its study committee have been enlisted. Study Committee members and other attendees commented on DPH's summary and asked questions. The question was posed as to whether these presumably high levels of asbestos in settled dust may have simply resulted from failure to comply with the current AHERA-based regulations. The location (floor tiles vs. other surfaces) of the microvacuum dust sampling that has been done thus far was also discussed.

2) Jim Millette provided an Introduction to Asbestos in Dust via powerpoint presentation, and attendee comments/questions ensued. Definitions for "dust," "debris," and similar terminology pertaining to asbestos were given. The serpentine vs. amphibole classification system for asbestos was described. Millette also provided both AHERA fiber definitions and OSHA (NIOSH) fiber definitions. Phase Contrast Microscopy Equivalent Analysis was explained. The Indirect Preparation method for microvacuum dust samples was outlined, and the importance of the comparison of such data with background levels was highlighted. Issues pertaining to fiber size were addressed.

3) The Planning Team asked questions of the Study Committee before the Committee began its own deliberations. The question of whether or not the current AHERA regulations were useful was raised. A request was also submitted that the Committee include in its recommendations some strategy aimed at the determination of point sources in schools.

4) Study Committee discussion: The question was posed as to whether dust sampling could even be considered a valid technique for any sort of assessment of risk. A consensus that microvacuum dust sampling did indeed have some utility was seemingly reached. However, several Committee members maintained that a thorough literature review of the relationship between fibers in dust and air should be undertaken before the absolute utility of microvacuum dust sampling can be established. The question of interpretation of the data was also addressed with regard to both airborne asbestos and dust sampling. It was suggested that the Committee reference a 1991 HEI-AR Report, *Asbestos in Public and Commercial Buildings: A Literature Review and Synthesis of Current Knowledge* for an appropriate airborne threshold. By way of a lengthy discussion, the group came up with a basic outline for the protocol to be followed by a given school system with regard to both periodic assessment and response to specific parent, teacher, staff, and community concerns. It was agreed that the same steps should be put in place for both the periodic assessment and the response to specific concerns. Namely, the first step would involve an inventory and record-keeping review of past management of ACM. This would include visual inspection of asbestos containing materials, a review of cleaning procedures, a review of records documenting procedures followed if ACM had been disturbed, and an updating of the asbestos management plan. If visual inspection and/or record-keeping indicated the possibility of asbestos contamination, surface sampling (using yet to be determined sampling techniques, locations, and analysis) would be indicated. If microvacuum dust surface sampling data came back above a particular threshold of fibers/cm2, activity-based air sampling would be invoked. Airborne data would serve as the basis for a final decision with regard to appropriate intervention. A decision was also reached that air sampling should report fibers/cc rather than structures/cc. Only fibers greater than 5μm in length would be counted, identified by way of 5000X TEM (Transmission Electron Microscopy), and there would be no distinguishing between asbestos fiber types. In conclusion, it was agreed that an initial flow chart would be drafted with what had been perceived as the initial decisions reached by the Committee. Gaps in knowledge and protocol would be highlighted, and committee members would receive the document via email. Each committee member would then have the opportunity to comment on the accuracy of the flow chart, and eventually members would be voluntarily assigned to further investigate the specific gaps in the decision tree.

APPENDIX A: SYNOPSIS OF COMMITTEE MEETING MINUTES

CASE Study Committee Minutes
An Evaluation of Asbestos Exposures in Occupied Spaces
Teleconference: Friday, October 29, 2004

Study Committee Members in attendance: Phil Apruzzese, Anne Bracker, Mark Cullen, Morton Lippmann, James Millette, David Pines, Gary Ritter, Matthew Willis; Academy Staff: Rick Strauss

1) Items which needed to be addressed in the current teleconference were identified. These items included: an air threshold concentration, a large fiber (>5µm) surface dust threshold, numbers of dust sampling locations, numbers of samples per location, a statistical analysis of dust data, clarification of the airborne sampling method, and a procedure for verifying that locations previously found to have ACM were no longer contaminated post-cleanup.

2) The committee was in agreement that the procedures outlined in Step 1 were appropriate. Step 2, "Seek Professional Advice," was then discussed. This step had initially been proposed as an amendment to the original draft out of concern that parents, teachers, administrators or health directors who have concerns about a given school's compliance with AHERA should be allowed the option of using multiple exposure assessment/remediation approaches in the event that visual inspection and/or record-keeping indicate that there has been potential asbestos contamination. The definition of what the committee meant by "licensed asbestos professional" was also discussed.

3) The committee then reviewed Step 3a, "Surface Dust Sampling." The two threshold criteria estimates for large fibers (>5µm) were re-introduced (originally developed by Jim Millette), and the methodology behind these calculations was discussed. It was suggested that the committee should clearly delineate that the threshold relates only to fibers longer than 5µm. The appropriateness of the 1991 HEI threshold of 0.0005 LF/cc for airborne sampling was also discussed. A suggestion was made that this value should be checked against any available data from Connecticut schools. The committee also considered the question of whether there exists in the literature enough health-based evidence to justify using only fibers longer than 5µm in the analysis, and a consensus was reached that there is ample evidence in this regard. A question was also raised as to whether there is currently an established, standardized protocol which laboratories can follow in order to count only long fibers: it was decided that Millette's proposed ASTM (American Society for Testing and Materials) D5755 appendix could fairly easily instruct laboratories on how to do this. A question was also posed as to whether Millette's calculation of an intervention threshold somewhere between 500-615 large fibers/cm^2 might be too conservative in that it might force schools to initiate costly intervention in situations where it might not be appropriate. The committee decided that it needs to be more certain that its recommendation is based on sound scientific data concerning the ratio of short to long fibers before specific threshold values are proposed. Committee members also emphasized that the proposed threshold value for dust is generally not supposed to represent a trigger for automatic abatement but rather for initiation of airborne sampling.

4) The next issues addressed were numbers and locations of samples that should be taken. It was suggested that 3 samples was an appropriate number, and that these initial 3 samples may trigger further surface dust sampling before the next step is initiated. It was also emphasized that background samples should be taken in order to validate the technique used and to show that a school's background values are lower than established background values. A consensus was reached that samples should only be taken from high contact areas, as opposed to behind radiators. "High contact areas" were defined as "those which children and non-maintenance school staff generally reach."

5) The committee then moved on to the issue of aggressive air sampling, referenced in Step 3b of the draft. After a lengthy discussion, a consensus was reached that rather than aggressive air sampling, the committee would simply recommend air sampling of classrooms where there is normal school-day activity if it is known that asbestos contamination is an issue. Additionally, in such cases periodic personal monitoring of custodial staff would also be recommended. (Note: please see the report for further information)

6) Within Step 3b, "Determination of Source" was next discussed. It was suggested that this section be moved to Step 2 ("Seek Professional Advice"). The investigation of air ducts as a potential source was discussed. It was asserted that concerns about air ducts cannot be addressed generally but rather should be addressed in a situation-specific manner. Step 4a ("Immediate Remediation of Location") was addressed. In general, the group agreed that more discretion should be left to the licensed professional as to the plan for remediation. In Step 4b, it was opined that the second bullet should be amended to be more specific. At the conclusion of the teleconference, it was decided that one of the tasks remaining involved a more clear delineation of Phase 1 vs. Phase 2 objectives.

APPENDIX A: SYNOPSIS OF COMMITTEE MEETING MINUTES

CASE Committee Minutes
An Evaluation of Asbestos Exposures in Occupied Spaces
Teleconference #2: Friday, November 19, 2004

Study Committee Members in attendance: Anne Bracker, Mark Cullen, Morton Lippmann, James Millette, John Morris, David Pines, Gary Ritter, John Vasselli, Matthew Willis; Academy Staff: Rick Strauss

1) The group reviewed the latest draft of the Flowchart/Decision Tree, focusing primarily on Step 3. The question at hand was the concern surrounding whether any one particular threshold value for long fibers in settled dust had an adequate scientific foundation as of yet. In particular, the following questions/issues were raised and discussed: (i) Is it appropriate to use the 8,000s/cm^2 number as the value by which to divide the experience-based ratio of short to long fibers? Several different benchmark values for asbestos in settled dust have been proposed, and these values differ by whole orders of magnitude. Are these different benchmark values comparable? (ii) Is it appropriate to use the short:long fiber ratio which Jim Millette had developed using sampling analysis sheets from only two school districts provided by the Connecticut Department of Public Health? (iii) Can a K value be selected to predict the resuspension of LF? K factors are currently in dispute in the professional community. (iv) If the LF threshold is developed by using the background levels of asbestos in air established by HEI (1991), anything above background could trigger concern and possible intervention. Is this appropriate?

2) The committee agreed that the examination and analysis of long asbestos fibers (>5μm) represents an exciting and appropriate direction to take. It was also concluded, however, that without better data in this area, the committee should not yet place a number on the long fiber threshold in settled dust but rather should advise consultants to recognize the limitations associated with interpreting results when structures of all lengths are counted. Since the value of dust sampling in general is currently heavily debated, the committee discussed whether or not the best approach to a situation of concern might be to proceed with air sampling and a good qualitative assessment. Limitations to both air sampling and surface dust sampling were noted.

3) There was some agreement that the available data are limited and that better background data are needed to make a reasonable determination of an acceptable risk level. The committee considered whether the best way to acquire such background information might be to take air samples from CT schools. It was also suggested that the best way to determine an action level for microvacuum dust samples might be to measure levels of fibers longer than 5μm in schools that have no asbestos containing materials and then derive the threshold level by multiplying by three to five times that number. The Committee also expressed in an interest in acquiring information on the serpentine content of rock formations in the State of CT to know whether or not the outdoors contributes to the indoor background levels. Concern was expressed that if the committee does not include a threshold number for dust samples, then any samples collected and analyzed can be viewed as potentially problematic. On the other hand, if the

committee were to include a number, misinterpretation might arise that the group is implicitly validating the microvacuum dust technique when there is not yet enough evidence to do so. The committee agreed that this particular objective should be addressed in Phase 2 of the project. The final Phase 1 document should cite the committee's lack of comfort with assigning particular values as of yet, and recommendations about the nature of the studies that are needed to determine such values should be made.

4) The timing of microvacuum dust sampling was discussed. Should microvacuum dust samples be taken before or after routine cleaning work? The point was raised that perhaps the best time for sampling would be at the end of a given janitorial cleaning cycle just before the area was routinely cleaned again.

5) A revision to the "Sample Analysis" bullet in Step 3a of the flowchart was suggested: labs should not simply count all fibers greater than 5µm but also characterize all long fibers found on the basis of their specific lengths. With regard to this same bullet, the committee was also asked to clarify its rationale for including only fibers greater than 0.1µm in the analysis, especially in light of the fact that more narrow fibers correlate with an increased mesothelioma risk. The reason for this width specification related to the fact that 0.1µm is generally considered to be the practical limit of what an analyst can see at 5000X magnification. As such, excluding narrower fibers standardizes the technique across various counters. The committee was informed that a revised flowchart and a draft of the accompanying narrative would be sent out by December 3, 2004. The committee would then be asked to review the material and send comments by Friday, December 10, 2004. The next meeting was tentatively scheduled for December 10.

APPENDIX A: SYNOPSIS OF COMMITTEE MEETING MINUTES

CASE Study Committee Minutes
An Evaluation of Asbestos Exposures in Occupied Spaces
Teleconference: Friday, December 10, 2004

Study Committee Members in attendance: Anne Bracker, Mark Cullen, Morton Lippmann, James Millette, John Morris, David Pines, Gary Ritter, John Vasselli, Matthew Willis; Academy Staff: Rick Strauss

1) The first item for review was microvacuum dust sampling – in particular, its current limitations and most appropriate usage. After some deliberation, the committee reached a consensus that it is not yet scientifically justified to state that microvacuum dust sampling can be used to determine the probability of airborne asbestos. Rather, it is more accurate to simply state that this type of sampling is a measurement tool for determining the presence and type of asbestos on surfaces. Furthermore, the committee articulated that microvacuum dust sampling is an assessment tool that should be used in conjunction with other tools/methods, rather than in isolation, in order to arrive at decisions regarding appropriate intervention. In addition, the committee expressed a desire to clarify that the most appropriate time for microvacuum dust sampling to take place is immediately before rather than immediately after a routine cleaning (i.e., at the end of a routine cleaning cycle). The committee agreed that these points should be more clearly delineated in the Step 3a portions of both the Flowchart and the Narrative.

2) The next issue related to the nature of the future study or studies necessary to determine whether or not it is possible to establish a statistically significant threshold value for long fibers of asbestos in settled dust. It was emphasized that such future studies should include dust sampling in CT schools that have been verified asbestos-free* in order to obtain accurate background levels. It was also suggested that the mean of these background dust samples from asbestos-free schools might be multiplied by a factor of three in order to derive a practical value on which to base decisions regarding intervention. The background samples referenced would be taken immediately before rather than immediately after a routine cleaning in order to provide an upper limit of the levels that are reached. In addition, it was also decided that the collection of background air samples would not be as helpful as dust samples in achieving this objective.

3) With specific regard to the narrative, several grammatical/stylistic and content revisions were suggested. In particular, the committee agreed to several changes regarding the explanation of the committee's attempts to calculate LF/cm2 threshold values for long asbestos fibers in settled dust. The committee also discussed the air threshold value put forth in Step 3b (0.0005 LF/cm3), agreeing that the HEI-AR panel from which this number came was very well-balanced, lending considerable authority to this source and its citation in the narrative.

* Subsequent to this meeting, a decision was made to change the term "asbestos-free" to "schools not known to have an asbestos contamination problem."

4) With regard to the schedule for post-remediation and post-cleanup/abatement sampling in Steps 4a and 4b, the committee did not feel equipped to recommend a precise timeline for subsequent testing. It was agreed that any already existing clearance criteria should not be modified, and that the final document should simply state that follow-up sampling should occur after a reasonable period has elapsed. One to three months was suggested in this regard.

5) It was explained to the committee that synopses of the minutes from each of the four meetings held would be included as an appendix to the final document. Committee members were also told that a revised narrative and flowchart would be sent via email by Friday, December 17, and that they would be asked to approve the final document or send further revisions via email by Wednesday, December 22.

APPENDIX B: LARGE FIBER COUNTING PROCEDURE

Draft
Intended as an Appendix to ASTM D5755-02
(Microvacuum Surface Dust Method)

A1. LARGE FIBER COUNTING CRITERIA

A1.1 Introduction

A1.1.1 The intent of this appendix is to provide information about producing a count of asbestos fibers equal to or longer than 5µm and wider than approximately 0.1µm in diameter. Individual large fibers rather than asbestos structures are reported. Examples of the various types of morphological structure, and the manner in which these are recorded are shown in Fig. A1.1. Phase Contrast Microscopy Equivalent (PCME) fibers are a subset of the large fibers counted under these rules.

A1.2 Structure Definitions and Treatment

A1.2.1 Designate each large fiber as a separate entity.

A1.2.2 Large Fiber—Define any particle with parallel or stepped sides, with a minimum length of 5.0 µm, a minimum diameter of 0.1 µm and with an aspect ratio of 3:1 or greater, as a large fiber. Define a bundle of fibrils meeting the minimum length, width and aspect ratio as a large fiber. Chrysotile large fibers will always be bundles. Assign a fiber with stepped sides a width equal to the average of the minimum and maximum widths. Use this average as the width in determination of the aspect ratio.

A1.2.3 PCM Equivalent Fiber -- any particle with parallel or stepped sides, with an aspect ratio of 3:1 or greater, longer than 5 µm, and with a diameter larger than 0.25 µm (NIOSH 7402). For chrysotile, PCM equivalent fibers will always be bundles.

A1.3 Other Structure Counting Criteria

A1.3.1. Large Fibers That Extend Outside a Grid Opening —During scanning of a grid opening, count fibers that extend outside a grid opening systematically, so as to avoid double-counting. In general, establish a rule so that fibers extending outside a grid opening in only two quadrants are counted. The procedure is illustrated by Fig. A1.2. Do not count fibers that cross two grid bars or do not have at least one end visible.

A2 Procedure

A2.1 Magnification — A magnification of approximately 5,000 times or higher may be used to count large fibers.

A2.2 Recording Large Fibers — On the counting form, record a fiber as defined in A1.2.2 by the designation LF. Record the fiber length and width. Count large fibers separately when they are part of a cluster or matrix.

A2.3 Procedure for Recording of Partially Obscured Large Fibers — If a fiber or bundle is obscured by other particulate and is longer than 2.5 µm, consider it a possible large fiber. The assigned length for each such partially obscured fiber or bundle shall be equal to the visible length plus the maximum possible contribution from the obscured portion. Count the particle as a large fiber if the assigned length, measured width and calculated aspect ratio meet the requirements of A1.2.2.

A2.4 Stopping Rules — Fiber counting may stop after the 25th large fiber counted or the completion of the grid opening resulting in the achievement of the analytical sensitivity required.

APPENDIX C: COMPARISON OF 0.0005 LF/CM³ AND 70 S/MM² AIR SAMPLING VALUES

0.0005 long fibers/cm³ –based on the average value of the air sample data from school buildings that were reviewed by the HEI committee. Fibers are longer than 5 µm with an aspect ratio of at least 3:1. The value is related to health effects through the lung cancer studies of asbestos worker populations. It represents a risk level of 6 premature cancer deaths per million exposed over a school attendance period of a number of years.

70s/mm² (on the air-sampling filter) - based on a cleanliness criterion used in the AHERA. The number is actually based on the background value of asbestos structures on some blank filters. (See a brief history below). The TEM count of structures includes asbestos fibers less than 5 µm in length (those greater than 0.5 µm with an aspect ratio of at least 5:1). It is not really related to a fiber per cc value because the volume of air is not specified. The 70s/mm² is a loading on a filter membrane. Although the EPA was adamantly opposed to listing any concentration in the AHERA document, some people have used the 70s/mm² and the minimum air volume that must be collected for AHERA (1,200 liters) to calculate a concentration of 0.022 s/cc. This value is not health based and is not considered to be corresponding to the 70 s/mm² by EPA.

0.01f/cc – A Phase Contrast Microscope (PCM) level that was listed in AHERA as the clearance level for small spaces – less than 3,000 square feet (AHERA p41851). This exclusion was to be valid only until October 7, 1989. Abatement of a small room was thought to be too small a project to require the clearance by 5 samples analyzed by TEM. Therefore, AHERA allowed the use of PCM to clear a small room. The level was based on ten percent of the OSHA permissible level. The count is by light microscopy of fibers that are longer than 5 µm, thicker than 0.25 µm and with an aspect ratio of at least 3:1. This value does not include a TEM confirmation that the fibers are asbestos.

Summary of Fiber Size Criteria

	Fiber Length	Fiber Diameter	Aspect Ratio	Fiber Type
0.0005 LF/cm³	>5µm	>0.1 µm	3:1	Asbestos
70 s/mm²	>0.5 µm	>0.02 µm	5:1	Asbestos
0.01 f/cc	>5 µm	>0.25 µm	3:1	Unknown

A BRIEF HISTORY OF 70STRUCTURES/MM^2

On October 22, 1986, President Reagan signed into law the Asbestos Hazard Emergency Response Act (AHERA). The Act required that EPA describe the methods used to determine completion of response actions such as the abatement of school buildings. Based on the data available at the time, EPA decided to use transmission electron microscopy (TEM) as the method for analysis. A simplified version of the prevailing TEM asbestos analysis method of the time, known as the Yamate draft method, was used to create a rapid method for the clearance of school buildings. Following the deliberations of a panel of asbestos analysis experts, the "Interim Transmission Electron Microscopy Analytical Methods" were published in the Federal Register on Oct. 30, 1987 as Appendix A to Subpart E to the EPA's "Asbestos-containing Materials in Schools; Final Rule and Notice."

The AHERA Method maintained many of the method particulars of the Yamate method but simplified the counting and recording for a rapid clearance procedure. As in the Yamate method, asbestos structures were counted. A structure was defined as a microscopic bundle, cluster, fibers, or matrix that may contain asbestos. A matrix was defined as a fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition. Under the AHERA method an asbestos fiber was defined as a structure greater than or equal to 0.5 µm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides. Individual dimensions of structures or fibers are not recorded under the AHERA method but information about the overall structure size is classified as either between 0.5 µm and 5.0 µm or greater than 5.0 µm. The size data is not used to determine compliance with the AHERA regulations but is included so if an area does not pass, the project manager might infer something about the source of the contamination. Many large structures found in the air would suggest improper cleaning while small structures could have come from a source external to the cleaning effort.

After an asbestos abatement but before the protective plastic barriers are removed, leaf blowers and fans are used to aggressively stir the air and resuspend any settled dust while five area air samples are collected. For abatement clearance, the five area air samples collected inside the containment were to be compared to five or more area air samples collected outside the containment. No aggressive disturbance of the air outside the containment was to be done. If there was no statistical difference between the two sets of samples, the abated area was cleared and prepared for reoccupancy. During the deliberations of the expert panel, the question was raised about whether all ten samples needed to be analyzed if no asbestos structures were found on the five inside-the-containment samples. Based on the experience of some of the panel in finding occasional asbestos fibers on blank (unused) polycarbonate filters, it was decided that a sample was clearly above the blank filter level if it had a filter loading greater than 70

structures per millimeter squared. In the real world abatement industry, the 70 str/mm^2 became the generally recognized clearance level and contractors are often instructed to reclean if the average of the five inside samples exceeded that value. Only rarely today is the comparison made of the five inside and five outside samples. Those few cases are usually where a contractor believes that asbestos contamination outside the containment area is contributing to the air within the abatement area.

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Eastern Research Group. Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk. Eastern Research Group, Lexington, MA (May 30, 2003). (See page vii)

The following four report titles are available at: http://www.epa.gov/wtc/draft_final_report.htm

World Trade Center Residential Dust Cleanup Program. Draft Final Report (March 2004)

World Trade Center Indoor Environmental Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks (May, 2003)

EPA's World Trade Center Residential Confirmation Cleaning Study

EPA's World Trade Center Background Study Report Interim Final (April 2003)

EPA. Draft Proposed Sampling Program to Determine Extent of WTC Impacts to the Indoor Environment. available at: http://www.epa.gov/wtc/panel/pdfs/sampling-proposal-20041015.pdf

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MAJOR STUDIES OF THE ACADEMY

2004

- Long Island Sound Symposium: A Study of Benthic Habitats
- A Study of Railcar Lavatories and Waste Management Systems

2003

- An Analysis of Energy Available from Agricultural Byproducts, Phase II: *Assessing the Energy Production Processes*
- Study Update: Bus Propulsion Technologies Available in Connecticut

2002

- A Study of Fuel Cell Systems
- Transportation Investment Evaluation Methods and Tools
- An Analysis of Energy Available from Agricultural Byproducts, Phase 1: *Defining the Latent Energy Available*

2001

- A Study of Bus Propulsion Technologies in Connecticut

2000

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- Indoor Air Quality in Connecticut Schools
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- Evaluation of MTBE as a Gasoline Additive
- Strategic Plan for CASE

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- Radon in Drinking Water

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- Agricultural Biotechnology
- Connecticut Critical Technologies

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- Evaluation of Critical Technology Centers
- Advanced Technology Center Evaluation
- Biotechnology in Connecticut

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- Science and Technology Policy: Lessons from Six Amer. States

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- A State Science and Technology Policy
- Electromagnetic Field Health Effects

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- Biotechnology (Research in Connecticut)
- Economic Impact of AIDS Health Care in Connecticut

1989

- Science and Engineering Doctoral Education in Connecticut

1988

- Indoor Pollution: Household Survey
- Vocational-Technical High School Curriculum Evaluation

1987

- Waste Conversion for State Construction
- High Technology Plan for Connecticut

1986

- Automobile Emissions Testing
- Health Standard (for EDBs)

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