TECHNICAL

"Living with TEM Clearance"

By Richard J. Lee and Ian M. Stewart

Introduction

In October of 1986, President Reagan signed into law the Asbestos Hazard Emergency Response Act (AHERA) mandating the Environmental Protection Agency (EPA) to take certain actions to control asbestos hazards in schools. Deadlines were set for EPA to perform these actions: if they did not, so-called "hammer clauses" in the bill took effect. One of these hammer clauses mandated the use of electron microscopy as a criterion for post-abatement clearance air monitoring. In response to AHERA, EPA convened a series of meetings under the negotiated rule-making process to formulate EPA's rules and regulations which implement AHERA.

A subcommittee, or task force, of leading microscopists from both private and federal laboratories was responsible for producing a sampling and analysis protocol suitable for post-abatement clearance monitoring. The microscopists selected had extensive experience in both scanning electron microscopy (SEM) and transmission electron microscopy (TEM) for airborne asbestos analysis.

The final rule defines TEM building clearance criteria which are based primarily on a comparison of airborne asbestos levels outside the worksite or building. The TEM method is operationally feasibl and the levels required for clearance ar achievable using good asbestos abatemen procedures.

Background

Phase contrast microscopy (PCM) ha been used extensively in the past for asbestos abatement clearance. However, PCM has two major limitations. First, it does not

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identify asbestos fibers, and may therefore, give erroneously high results by including other fibers, such as gypsum, mineral wood, or cellulose, from building products. Secondly, because of limited resolution small fibers with diameters less than ~.25 micrometers are not observed. These small fibers are believed to have major significance in carcinogenicity.

By contrast, the TEM specifically identifies asbestos fibers and can resolve even the finest asbestos fibers that may be present.

How Does it Work?

As in the case of phase contrast microscopy, samples of the airborne asbestos are collected by pulling air through a very fine filter, either a polycarbonate filter having a pore size less than or equal to .4 micrometers, or a mixed-cellulose ester filter having a pore size less than or equal to .45 micrometers.

Five samples are taken in the abatement area after the primary containment barriers have been removed, the abatement area has been thoroughly dried and it has passed visual inspection tests. These samples must be taken on a random basis in order to adequately sample the air remaining in the containment area. Similarly, five ambient samples must be taken outside the containment area, which are representative of the makeup air entering the abatement site. A sealed blank and two field blanks, one taken at one of the ambient sites and one taken in the containment area, complete the sample set.

The samples are transported to the laboratory where a direct preparation technique is required to produce a suitable preparation for TEM examination. It is important that the TEM used by capable of performing electron diffraction, that it have a flourescent screen with calibrated gradations for measuring fiber sizes, and that energy dispersive x-ray analysis, which provides information on chemical composition, be available. The combination of electron diffraction and energy dispersive x-ray analysis is used to identify fibers or fiber structures as asbestos.

Specific asbestos structures are identified in groups and are split into four classes: asbestos fibers, asbestos bundles, asbestos clumps, and asbestos matrices. The rule defines and illustrates each structure and further defines some detailed criteria by which asbestos shall be identified. Because asbestos structures in small quantities are ubiquitous the blanks may contair asbestos structures introduced during filte manufacture, handling in the field, o preparation and analysis in the laboratory Thus, the rule takes cognizance of this fac and places a limit on the number of structures per square millimeter of filter sur face, which is considered to be statisticall indistinguishable from filter contamination. This criterion is expressed by struc tures per square millimeter because th contamination may originate from source other than the air being sampled and thu cannot be meaningfully expressed as a concentration per cubic centimeter of air

How do I Pass or Fail?

Under the present sampling require ments, at least 13 samples are collected fo the clearance testing and abatement site These include five abatement area sam ples, five ambient samples, two fiel blanks, and one sealed blank. Not all thes samples, however, may need to be ana lyzed. The analysis starts with the fiv abatement area samples. If the averag fiber content of those five samples is les

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than 70 structures per square millimeter of filter area, the samples are not significantly different from background as defined earlier. Thus, they meet the clearance standard and it would be unnecessary to analyze the ambient or blank samples. The abatement area is cleared, the final containment barriers may be removed and the building may be reoccupied.

If the average fiber count is more than 70 structures per square millimeter, there are two options; either the site may be recleaned or the blanks may be analyzed. If the blanks yield concentrations of fibers greater than 70 structures per square millimeter, there has been some contamination during the sampling or analytical procedure. The contamination problem must be resolved and new samples must be collected and analyzed.

If the blanks show concentrations less than 70 structures per square millimeter, then the five ambient samples are analyzed. The airborne asbestos concentrations taken inside the containment barrier are then compared statistically with the air concentrations of the outside ambient air using a statistical test—the Z-test. If the abatement area samples are not significantly different in concentration from the ambient control samples, the area meets the clearance criteria, the barriers come down, and the contractor leaves. If the abatement area samples are significantly higher than the ambient asbestos concentration then the abatement area must be recleaned and the air sampling and analysis procedure repeated. Figure 1 shows this procedure in the form of a flowchart.

Can I Still Use Phase Contrast Microscopy?

The answer to this question is a qualified "yes." TEM is required under this rule for all major asbestos abatement projects. Major projects are defined as those where the area of material to be removed is greater than 2999 square feet or a linear pipe length of 999 feet. Phase contrast microscopy is permissible for projects which are smaller than this. TEM, however, will be phased in as a requirement for all projects. The phase-in will be performed in two stages. TEM will be required 721 days after promulgation of the rule for projects where equal to or greater than 1500 square feet or 500 linear feet of asbestos are to be removed. TEM will be required for all asbestos abatement projects, regardless of size, 1081 days after promulgation of the rule. The pass-fail criterion for PCM on minor projects requires multiple samples, with clearance allowed only if all of the individual samples are below the limit of reliable quantification of the PCM protocol which is defined as 0.01 fibers per cc.

Can I Pass?

TEM clearance procedures have been appearing in specifications with increasing frequency over the last couple of years, and there is now a good body of data available to indicate that a contractor using good work practices throughout the entire abatement project and a thorough multi-stage cleaning process can meet the TEM clearance criteria. The importance of using good work procedures to control asbestos fibers throughout the entire project cannot be too highly stressed. These make the ultimate cleanup a more straightforward process with much higher probability of passing the final clearance.

About the Authors

Richard J. Lee is President, and Ian M. Stewart, Vice President of Project Development, of Energy Technology Consultants (ETC), a leader in the field of asbestos determination.

Lee was formerly head of the advanced electron microscopy group of USX Research Laboratories and has over 15 years' experience on determination of asbestos in water and air samples. He has participated actively in asbestos methodology workshops and task forces sponsored by the EPA, National Bureau of Standards, and the American Society of Testing Materials. He was a member of the select committee which prepared the transmission electron microscopy methodology for EPA's rules and regulations.

Stewart was formerly Vice President of McCrone Associates and McCrone Environmental Services, Inc., and has been an active participant in EPA, NBS and ASTM workshops and task forces on asbestos methodology since 1970. He is a past President of the National Asbestos Council and a former Chairman of its Ethics Committee.

Energy Technology Consultants (ETC) is a leader in the field of the application of electron microscopy to problem solving. It has pioneered many advances in computer controlled electron microscopy and image analysis. ETC's TEM asbestos analysis group was responsible for preparing the final written draft submitted by the select committee to EPA for the asbestos methodology to be used in final clearance. ETC has recently opened a second electron microscopy laboratory in Berkeley, California.