pennsylvania
DEPARTMENT OF ENVIRONMENTAL
PROTECTION

January 21, 2020

Erskine Environmental Consulting
Bradley G. Erskine, Ph.D., CEG, CAC
401 Marina Place
Benicia, CA 94510

Re: Standard Operating Procedures for the
Asbestos Differential Counting Method
Utilized by EMSL Laboratories and R.J. Lee Group

Dear Dr. Erskine:

This letter is in response to your letter dated December 2, 2019, requesting the Standard Operating Procedures (SOPs) for the asbestos differential counting method utilized by EMSL Laboratories and R.J. Lee Group for the identification of asbestos at the Rock Hill Quarry. The Department has obtained that documentation, which is included in this correspondence.

Sincerely,

Gary A. Latsha
District Mining Manager
Pottsville District Office

cc: John J. Stefanko, Deputy Secretary
Dan Sammarco, Director DMO
Michael Kutney, P.G., EGM
Craig Lambeth, Office of Chief Counsel
Patrick Patterson, SERO
Sachin Shankar, SERO
James Rebarchak, SERO
Shawn Mountain, SERO
Neil Shader, Director of Communications
Virginia Cain, SERO
Rob Fogel, CRRC DEP
Marianne Morano, East Rockhill Township Manager
Andrew Gutshall, P.G., Hanson Aggregates
Curt Mitchell, R.E. Pierson
File
MS1-Erskine (1.20)

GAL:cmb

Fogel, Robert

From: Ellis, Benjamin <bellis@EMSL.com>
Sent: Wednesday, January 8, 2020 11:49 AM
To: Latsha, Gary
Cc: Cahill, Ed; Ray, Robyn
Subject: [External] RE: Standard Operating Procedures (SOP's) for the Asbestos Differential Counting Method

Gary,

Below we have provided background information on what constitutes asbestiform structures and the decision making process used by EMSL during analysis on your samples.

Regards,

Ben

Differentiating true asbestiform fibers from cleavage fragments of the same mineral is often an important distinction when attempting to determine applicability of existing regulations and danger from exposure. Unfortunately the distinction between asbestiform and non-asbestiform on a fiber by fiber basis is difficult at best and is often based on subjective morphological observations. Even the importance of the distinction between asbestiform and other fibers with similar dimensions is subjective and highly debated.

Though the data end users typically look to the laboratory to make the critical distinction between asbestiform and non-asbestiform, it should be recognized that the distinction can be subjective. It is important that the client and the laboratory have a discussion prior to analysis, about the specific criteria to be applied.

EMSL endeavors to provide as much information as possible about what fibers were and were not included as part of the asbestiform count and why so that the end user has an accurate picture of what the analyst encountered during the analysis. The level of effort and the degree of documentation to be employed should be part of the initial conversation between the laboratory and the client.

Since the asbestiform and non-asbestiform manifestations of a particular mineral can have identical chemistry and crystallography at the microscopic level, the primary distinctions are made by morphology (size and shape) of the elongate mineral particles (EMPs) in question. Because of this, it is extremely important to recognize that the preparation steps that the laboratory employs can have a profound impact on the size and shape of the fibers observed during analysis.

Preparation steps for the analysis of manufactured products are specific to the material in question, and are chosen to identify components, minimize or reduce interferences and aid in the detection and identification of the mineral fibers present. All of the preparation steps are chosen to minimize the comminution of EMPs as much as possible while recognizing that a proper light or transmission electron microscopy preparation and analysis requires a fairly small particle size.

The specific criteria outlined in the analytical methods significantly affect the final results that are reported. These criteria typically do not address distinguishing asbestiform from non-asbestiform EMPs. Laboratories are left with ambiguous and subjective definitions for fibers that change with the method being employed.

The asbestiform habit is best defined at the macro scale on hand samples and not the micro scale on individual fibers. None of the current asbestos methods can unambiguously classify a countable fiber as asbestiform vs. cleavage fragment in all cases. Furthermore, it cannot be unambiguously stated that non-asbestiform fibers can be dismissed as non-contributors to asbestos related diseases.

Of particular concern in this differentiation challenge is the presence of cleavage fragments. Cleavage fragments are particles that can result from the comminution (natural or manufactured) of a non-asbestos amphibole or other mineral. Cleavage fragments have the potential to be elongate, and if they have the same chemistry as the asbestiform variety of a specific mineral, they will be counted as a fiber during analysis.

Below are some common definitions.

Asbestiform

The unusual crystallization habit of a mineral when the crystals are thin, hair-like fibers. With a light microscope, this habit is recognized in a bulk hand sample by the following characteristics:

- Mean aspect ratio ranging from 20:1 to 100:1 or higher for fibers longer than 5 um. Aspect ratio should be determined for fibers, not bundles.
- Very thin fibrils, usually less than 0.5 um in width.
- Two or more of the following:
  - parallel fibers occurring in bundles
  - fiber bundles displaying splayed ends
  - matted masses of individual fibers
  - fibers showing curvature

Asbestos

A commercial industrial term rather than a mineralogical term referring to well-developed and hair-like long-fibered varieties of certain minerals that satisfy a particular industrial need.

Cleavage fragments

Mineral particles resulting from the fragmentation of non-asbestiform amphibole. Some may have dimensions of a countable fiber, by whatever counting method employed. (I.e. AHERA length = >0.5 um, aspect ratio of 5:1; NIOSH 7402 length = >5 um, width 0.25 - 3.0 um)

Elongate mineral particle (EMP)

A mineral particle with an aspect ratio (length: diameter) greater than 3:1, irrespective of whether its origin is asbestiform or non-asbestiform.

Mineral

A naturally occurring inorganic substance having a defined chemical composition and crystal structure.

Analysis by Transmission Electron Microscopy (TEM)

The high magnifications (typically 20,000X and above) employed in TEM analysis allow the analyst to see fibers that are well beyond the limit of resolution of light microscopy.

This high magnification however limits the amount of sub-sample that can be prepared and analyzed. It is therefore more difficult to assess the entire population of fibers present, if indeed a population has been collected onto the filter. TEM analysis involves more analysis and decisions on a fiber by fiber basis. The lab can characterize the fibers present in the sample with a particle size distribution that includes average length, width, aspect ratio etc. however on a fiber by fiber basis subjective decisions need to be made on the basis of morphology as to whether the particle is to be included in the overall count.

EMSL recognizes that as a service laboratory and not a risk assessor or health expert, we can only provide the most accurate and transparent data possible in an effort to inform our client what is present in the sample. The potency of non-asbestiform fibers or non asbestos (non-regulated) minerals, to induce cancer or cause other asbestos related disease is still debated. Therefore, after consulting with the client, we will attempt to distinguish non-countable minerals from countable ones on morphology. In a scientific approach to this technical challenge, EMSL has adopted the following criteria for differentiation of asbestos vs. non-asbestos elongate particles.

- For a countable fiber, the structure will need to meet the definition of a fiber as counted by the method in regards to length, width and aspect ratio. All visible edges of the fiber should be substantially parallel.
- There is some subjectivity to the determination, especially if the fiber is attached to a matrix. If the edges are obscured by matrix or other debris and cannot be conclusively determined, it will be regarded as method countable fiber.
- Elongate mineral fibers of amphiboles with pointed terminations (acicular), Rounded or cleft sides or ends, or do not meet aspect ratio will be counted as non-countable elongate mineral fibers (Non- Asbestiform)

In addition to morphology, confirmation by chemistry (energy-dispersive x-ray spectroscopy) and by diffraction (selected-area electron diffraction) will also be provided. Chemistry and diffraction may be used to reject a particle as asbestos regardless of morphology if the particle is clearly not a regulated mineral. Both countable and non-countable EMP's will use semi quantitative EDXA to determine the mineral species. In the course of the analysis, numerous EMPs which match the mineralogy and chemistry of asbestos may nevertheless be excluded from being asbestos due to their physical/structural form.

Background References

Useful references include primarily documents related to PLM analysis of asbestos, though the morphological descriptions of asbestiform characteristics and cleavage fragment characteristics translate somewhat to TEM analysis.

- EPA-600/M4-82-020 (Interim Method for the Determination of Asbestos in Bulk Building Materials), December 1982
- EPA-600/R-93/116 (Method for the Determination of Asbestos in Bulk Building Materials), July 1993
- OSHA Method "Polarized Light Microscopy of Asbestos", February 1995
- J. Occup. Environ. Hyg., Dec. 2008, M. Harper et al., "Differentiating Non-asbestiform Amphibole and Amphibole Asbestos by Size Characteristics"
- AIHA Journal, 1985, A. Wylie et al., "Characterizing and Discriminating Airborne Amphibole Cleavage Fragments and Amosite Fibers: Implications for the NIOSH Method"
- Asbestiform Fibers: Non-occupational Health Risks, 1984, National Academies Press
- The Habit of Asbestiform Amphiboles: Implications for the Analysis of Bulk Samples, 1999, A. Wylie, ASTM Publication STP1342
- NIOSH Roadmap

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From: Ellis, Benjamin
Sent: Thursday, December 05, 2019 9:44 AM
To: 'Latsha, Gary' <galatsha@pa.gov>
Subject: RE: Standard Operating Procedures (SOP's) for the Asbestos Differential Counting Method

Gary,

I am working with QA and management to get you a releasable document to you. As the way they stand now they are confidential business documents and cannot be distributed. I will get back to you shortly.

Regards,

Ben

Benjamin Ellis, M.S. | *Senior Scientist – Special Projects*
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From: Latsha, Gary [mailto:galatsha@pa.gov]
Sent: Tuesday, December 03, 2019 9:46 AM
To: Ellis, Benjamin <bellis@EMSL.com>
Subject: Standard Operating Procedures (SOP's) for the Asbestos Differential Counting Method

[EXTERNAL E-MAIL]

Good Morning Mr. Ellis; It is my understanding that EMSL would have Standard Operating Procedures (SOP's) for the asbestos differential counting method utilized by the EMSL Laboratories. Can you provide an actual SOP where the procedures used to implement the specific differential counting protocols to selectively separate particles in the application of EPA Method 600/R-93/116 to report asbestos? Thanks!
Gary

Gary A. Latsha | District Mining Manager
Department of Environmental Protection
Pottsville District Mining Office
5 West Laurel Boulevard | Pottsville, PA 17901
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Hanson
HEIDELBERGCEMENT Group

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7660 Imperial Way
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Tel 610-366-4600
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Sent via e-mail only

January 15, 2020

Gary A. Latsha
District Mining Manager
Pottsville District Mining Office
Pennsylvania Department of Environmental Protection
5 West Laurel Boulevard
Pottsville, PA 17901

Re: Transmittal of RJ Lee Group January 14, 2020 Letter
Rock Hill Quarry
Hanson Aggregates Pennsylvania LLC
SMP # 7974SM1
East Rockhill Twp., Bucks Co., PA

Mr. Latsha:

Hanson Aggregates Pennsylvania LLC (Hanson) is providing the attached January 14, 2020 letter from RJ Lee Group (RJLG) regarding the methodology used to differentiate asbestiform amphibole fibers from their non-asbestiform analogs.

Please feel free to contact me at (610) 366-4819 should you wish to discuss this submission.

Regards,

Andrew J. Gutshall, P.G.
Area Environmental Manager

encl: RJ Lee Group letter to Andrew J. Gutshall, P.G. dated January 14, 2020

cc: John Stefanko, PADEP
Daniel Sammarco, P.E., PADEP
Michael P. Kutney, P.G., PADEP
Amiee Bollinger, PADEP
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Matthew S. Burns, Esq., Hanson
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Environmental File

RJ LEE GROUP
DELIVERING SCIENTIFIC RESOLUTION

January 14, 2020

Mr. Andrew J. Gutshall
Hanson Aggregates Pennsylvania LLC
7660 Imperial Way
Allentown, PA 18195-1040

RE: Regulations of Asbestos Minerals
RJ Lee Group Project Number: LLH901997

Mr. Gutshall,

A request[1] by the Pennsylvania Department of Environmental Protection (DEP) was made on December 4, 2019 for the methodology used by RJ Lee Group (RJLG) to differentiate asbestiform amphibole fibers from their non-asbestiform analogs. This request appears to have been prompted from comments made by B. Erskine related to various analyses performed by RJLG on samples from the Rock Hill Quarry.[2]

Background

Numerous samples of varying matrices (air, water, and bulk) from the Rock Hill Quarry have been analyzed to determine the amount and type of asbestos present in the samples. To date, the only minerals detected that could be asbestos are from the tremolite/actinolite solid solution series.[3] No serpentine minerals have been observed at this deposit. The actinolite occurs in a variety of growth habits, ranging from asbestiform fibers to prismatic, non-asbestos particles.

The Federal government regulated six minerals (one serpentine and five amphibole minerals) as asbestos when they occur in the asbestiform habit. The minerals are listed in Table 1 which is taken from a recommended US Environmental Protection Agency (EPA) analytical protocol (EPA 600/R-93/116):

[1] G. Latsha (2019). Email to A. Gutshall, December 4, 2019.
[2] B. Erskine (2019). Letter to M. Kutney and G. Latsha, December 2, 2019.
[3] B. E. Leake, et al. (1997). "Nomenclature of Amphiboles: Report of the Subcommittee on Amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral Names", *The Canadian Mineralogist*, 35, p. 219-246. Note: there are more recent publications by this subcommittee (Leake et al 2004 and Hawthorne et al 2012) that update amphibole nomenclature, but these have not altered the tremolite/actinolite definition.

Table 1. The asbestos minerals and their nonasbestiform analogues

Asbestiform	Nonasbestiform	Chemical Abstract Service No.
Serpentine		
Chrysotile	Antigorite, lizardite	12001-29-5
Amphibole		
Anthophyllite asbestos	Anthophyllite	77536-67-5
Cummingtonite-grunerite asbestos (Amosite)	Cummingtonite-grunerite	12172-73-5
Riebeckite asbestos (Crocidolite)	Riebeckite	12001-28-4
Tremolite asbestos	Tremolite	77536-68-6
Actinolite asbestos	Actinolite	77536-66-4

Reproduced from Table 2-6 of EPA 600-R-93/116

As suggested by the above Table, these minerals occur in a variety of growth habits, broadly classed as "asbestiform" and "nonasbestiform". The vast majority of any of these minerals occur as non-asbestos particles (nonasbestiform) and are common rock-forming minerals worldwide.

The asbestiform varieties of these six minerals are regulated by various agencies of the Federal government. Three relevant agencies (EPA, OSHA, and MSHA) regulate the asbestos fibers, describing them as either "asbestos" or "asbestiform". OSHA discussed the literature related to non-asbestos amphiboles in 1992 and concluded that they would not be regulated as if they were asbestos fibers.

Both EPA and OSHA cite to the work by Campbell, et al[4] to describe what is and what is not asbestos. Portions of Campbell are included (copied) in the appendices to OSHA's regulations. Campbell et al defines asbestos as follows:

> Asbestos.--(l) A collective mineralogical term encompassing the asbestiform varieties of various minerals; (2) an industrial product obtained by mining and processing primarily asbestiform minerals.

They further define asbestiform as:

> Asbestiform.--A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility. The definition of asbestiform minerals includes three aspects: morphology, structure, and chemistry. Morphologically, asbestiform mineral varieties separate into flexible fibers or flexible bundles of fibers.

In 1994, the EPA issued a notice (*Federal Register*, 59, p. 38970-38971) to the analytical community that there was an improved, but not promulgated, PLM analytical method (EPA 600/R-93/116) and recommended its usage. Contained in that method is a definition of "asbestiform":

[4] W. J. Campbell, et al. (1977). "Selected Silicate Minerals and Their Asbestiform Varieties - Mineralogical Definitions and Identification-Characterization", Bureau of Mines, United States Department of Interior, Information Circular 8751.

> "**Asbestiform (morphology)** - Said of a mineral that is like asbestos, i.e., crystallized with the habit of asbestos. Some asbestiform minerals may lack the properties which make asbestos commercially valuable, such as long fiber length and high tensile strength. With the light microscope, the asbestiform habit is generally recognized by the following characteristics:
>
> - Mean aspect ratios ranging from 20: 1 to 100: 1 or higher for fibers longer than 5µm. Aspect ratios should be determined for fibers. not bundles.
> - Very thin fibrils, usually less than 0.5 micrometers in width, and
> - Two or more of the following:
>   - Parallel fibers occurring in bundles,
>   - Fiber bundles displaying splayed ends,
>   - Matted masses of individual fibers, and/or
>   - Fibers showing curvature
>
> These characteristics refer to the population of fibers as observed in a bulk sample. It is not unusual to observe occasional particles having aspect ratios of 10:1 or less, but it is unlikely that the asbestos component should be dominated by particles (individual fibers) having aspect ratios of <20:1 for fibers longer than 5µm. If a sample contains a fibrous component of which most of the fibers have aspect ratios of <20:1 and that do not display the additional asbestiform characteristics, by definition the component should not be considered asbestos."

RJLG used the EPA 600/R-93/116 procedure to analyze various bulk (rock) samples. Because the submitted samples were too large for microscopic analyses (by any microscopic technique), the samples were initially prepared using the grinding procedure described in CARB 435[5]. The ground material was then homogenized using a random-orbital mixer prior to removing any aliquots for analyses.[6]

Differentiation of Asbestos Fibers and Non-Asbestos Particles

The request from the DEP is for the RJLG standard operating procedure (SOP) used in this project to make a differentiation between asbestos fibers and non-asbestos particles. RJLG does not have a formal SOP for this action but relies on more than 40 years of experience analyzing amphibole minerals. Dr. Lee began the initial investigations into amphibole mineralogy back in the 1970's as it was relevant for the taconite mines (related to Reserve Mining) and how that would relate to the mines operated by US Steel. These issues, discussed by the US Bureau of Mines[7,8,9] in their publications from the 1970's-1980's, form the

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[5] Air Resources Board (1991). *Determination of Asbestos Content of Serpentine Aggregate*, California Environmental Protection Agency, Method 435, adopted June 6, 1991.

[6] Air Resources Board (2017). *Implementation Guidance Document: Field Sampling and Laboratory Practices; Air Resources Board Test Method 435: Determination of Asbestos Content of Serpentine Aggregate*, California Environmental Protection Agency, April 2017.

[7] W. J. Campbell, et al. (1977). "Selected Silicate Minerals and Their Asbestiform Varieties - Mineralogical Definitions and Identification-Characterization", Bureau of Mines, United States Department of Interior, Information Circular 8751.

[8] W. J. Campbell, et al. (1979). "Relationship of Mineral Habit to Size Characteristics for Tremolite Cleavage Fragments and Fibers", Bureau of Mines, United States Department of Interior, Report of Investigations 8367.

[9] W. J. Campbell, et al. (1980). "Chemical and Physical Characterization of Amosite, Chrysotile, Crocidolite, and Nonfibrous Tremolite for Oral Ingestion Studies by the National Institute of Environmental Health Sciences"." Bureau of Mines, United States Department of Interior, Report of Investigations 8452.

basis for current Federal regulations. These characteristics were discussed by OSHA in their 1992 rulemaking (see the preamble for the 1992 rulemaking, Federal Register, June 8, 1992).

EPA's recommended procedure (EPA 600/R-93/116) contains a detailed description of "asbestiform" (see above) which provides information on when to count and when not to count a particle as "asbestos". This procedure incorporates two microscopy procedures (polarized light microscopy – PLM and transmission electron microscopy – TEM). Thus, such a definition is not limited to one set of particles but applies to all observable particles.

RJLG personnel have been investigating the characteristics of amphibole minerals for more than 40 years and have published numerous papers related to this research. As noted above, RJLG does not have an SOP that outlines a step-by-step procedure that can be used to make the asbestos/non-asbestos differentiation. Instead, we rely on the more than 40 years' experience for those criteria.

Various publications have detailed these differences between these growth habit, with Langer et al being an example of just such a detailed procedure.[10] In 1984, there was a meeting where principals in the field of mineralogy agreed to a common definition of asbestos.[11] In a simpler form, this definition was adopted into the 1993 EPA PLM method (EPA 600/R-93/116) and into the more recent ISO PLM methods (ISO 22262-1).

RJLG personnel have examined numerous samples of amphibole minerals that can readily be characterized as either "asbestos" or "non-asbestos". These investigations have resulted in several publications that both discuss the differences of the dimensions of such particles[12,13] as well as how the morphological and microscopical differences can be used to differentiate these particles.[14,15,16] Such procedures were approved by the EPA for use in differentiating "asbestos" from "non-asbestos" during the investigation into the possible contamination at the Southdown quarry in New Jersey.[17]

The process used by RJLG is backed by many years of research and experience and is supported by work by other investigators. Differentiation of the amphibole minerals into "asbestos" and "non-asbestos" is not a trivial matter and represents one of the thorny issues for laboratories and investigators whose

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[10] A. M. Langer, et al. (1991). "Distinguishing Between Amphibole Asbestos Fibers and Elongate Cleavage Fragments of Their Non-Asbestos Analogues", *Mechanisms in Fibre Carcinogenisis*, p. 253-267.
[11] M. Ross, et al. (1984). "A Definition for Asbestos", *Definitions for Asbestos and Other Health-Related Silicates*, ASTM STP 834, Benjamin Levadie, Ed., American Society for Testing and Materials, Philadelphia, p 139-147.
[12] D. R. Van Orden, et al. (2009). "Width Distributions of Asbestos and Non-Asbestos Amphibole Minerals", *Indoor and Built Environment*, 18, p. 531–540.
[13] D. R. Van Orden, et al. (2016). "Determination of the Size Distribution of Amphibole Asbestos and Amphibole Non-Asbestos Mineral Particles", *The Microscope*, 64, p 13 – 25.
[14] M. S. Sanchez, et al. (2008). "Extinction Characteristics of Six Tremolites with Differing Morphologies", *The Microscope*, 56, p. 13-27.
[15] D. R. Van Orden, et al. (2005). "A Review of the Analysis of Amphibole Fibers", presented at the SME Annual Meeting, Salt Lake City, UT, February 28 – March 2, 2005. Pre-print 05-75.
[16] D. R. Van Orden, et al. (2008). "Differentiating Amphibole Asbestos from Non-Asbestos in a Complex Mineral Environment", *Indoor and Built Environment*, 17, p. 58-68.
[17] D. W. Berman (2003). "Analysis and interpretation of measurements for the determination of asbestos in core samples collected at the Southdown Quarry in Sparta, New Jersey", Report of analysis, Aeolus, Inc., November 12, 2003.

primary experience is with the serpentine minerals which comprise the vast majority of asbestos used in the US as well as the most frequently encountered mineral that can be a naturally occurring asbestos.

If you have any questions concerning these issues, please feel free to contact me. I can provide you with copies of these referenced documents if requested.

Sincerely,

Drew R Van Orden

Drew R. Van Orden, PE
Senior Consulting Scientist