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SUMMARY OF ASBESTOS ANALYSIS OPTIONS FOR TALC

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Background

Several different techniques are utilized for the identification of asbestos. Each method has applicability to a specific situation, and each method has advantages and disadvantages. Therefore, there is no one technique that is superior to all others; rather, the situation and information required will determine the best method to be used. A brief summary of techniques is included in the attached table.

The need for both TEM and SEM/PLM analysis:

- If a suspect phase is present in talc ore it often, *but not always*, shows macro-morphological features associated with asbestos, a notable exception being the St. Pierre de Broughton deposit. The definition proposed by Dr. Ann Wiley, and adopted by OSHA and MSHA, was meant to apply to the size range of particles that are visible by optical microscopy (i.e. PLM), and when enough fibers are present to evaluate the following population characteristics (at least two of the following must be present in the population):
    - Parallel fibers (fibrils) occurring in bundles,
    - Fiber bundles displaying splayed ends,
    - Matted masses of individual fibers (fibrils), and/or
    - Fibers showing curvature

- When ore containing asbestos is ground into product, bundles can be disaggregated into individual fibrils which do not individually possess the above listed characteristics, but can nonetheless be countable by regulatory entities (i.e. >5 μm in length). Individual fibrils less than 0.25 μm may not be resolved and/or characterized by PCM, PLM or conventional SEM, *even if they are greater than 5 μm in length*. This is especially true for chrysotile (which is typically finer than the amphiboles).

- Individual fibrils, if present, can be resolved and characterized using ISO, NIOSH, EPA and ASTM air and dust methods that are based on TEM. Some of these methods require counting only fibers greater than 5 μm in length; some include fibers less than 5 μm in length as well.

- It is impossible to distinguish *individual* asbestiform fibrils from cleavage fragments of the same dimension (especially if occurring in trace amounts) because macro-morphological growth features are not present. This is true for TEM as well as SEM, the difference being that the SEM is not likely to resolve such fibrils. In this situation, aspect ratio, minimum length, and maximum width become the only parameters for fibril characterization, and these parameters are as yet not well defined within the asbestos regulation community. The inability to distinguish asbestiform fibers from elongated cleavage fragments is therefore more related to the type and size range of sample being analyzed than it is to the technique being utilized.

- Regulation relating to product labeling (if asbestos is present) is based on quantity regardless of fiber size (labeling threshold is 0.1% or 1000 ppm). Regulation relating to exposure to respirable dust (i.e. during milling and/or product use) is based on fiber quantity per volume air and applies to fibers greater than 5 μm in length, but with very restrictive aspect ratio restrictions (3:1 by OSHA and MSHA; 5:1 by ISO, EPA, and ASTM). In any case, regulatory compliance does not necessarily imply an absence of litigation risk.

- If fibers are detected in air or dust samples by TEM, it may become necessary for a potential defendant to prove that these fibers were originally non-asbestiform. Historical SEM analysis of the ore may become important in this situation.

- **The risk of relying on SEM or PLM alone for product analysis is that individual asbestiform fibrils could be missed (especially chrysotile).**

- **The risk of relying on TEM alone for product analysis is that suspect amphibole particles may be classified as asbestiform, when in fact, they are cleavage fragment fibers.** Note that TEM *can* be used exclusively for chrysotile analysis, since chrysotile can be completely characterized as asbestiform by TEM.

- The best strategy to fully characterize ore/product samples is to use a combination of techniques, including PLM, SEM and TEM, along with XRD for isolated confirmation of major phases encountered in the ore.
    - The advantage of starting with TEM analysis is that a "non-detect" result unequivocally means that the sample does not contain asbestos (if asbestos is present in the coarser size fraction it will also likely be present in the finer size fraction. Additional analysis may be required for positive results, but only if amphiboles are present.
    - Alternatively, a "non-detect" result by SEM means that asbestos is not present in the coarser size fraction. Additional TEM analysis should periodically be performed to confirm the absence of asbestos in the finer size fraction.

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Technique	Description	Applicable Fiber Size Fraction	Detection Limit	Use/ Advantage	Disadvantage
X-ray diffraction (**XRD**)	Best technique to confirm if amphibole and/or serpentine is present in major quantity (>0.5 – 1%).	Confirms major occurrence regardless of size/morphology.	0.5 – 1% (5000 – 10,000 ppm) regardless of size	Used as a screening tool for major occurrences.	Cannot distinguish asbestiform from non-asbestiform; less sensitive.
Phase contrast microscopy (**PCM**)	Measures all fibers based only on aspect ratio. Results based on volume of air collected.	**Long fibers only** (length >5 µm; width >0.25 µm)	Dependent on volume of air collected.	Used primarily for abatement clearance; as a screening tool.	Cannot distinguish asbestiform from non-asbestiform; cannot resolve individual fibrils.
Polarizing light microscopy (**PLM**)	Uses optical properties and macro-morphological factors for identification of asbestos.	**Long fibers only** (length >5µm; width >0.25 µm)	0.1% (1000 ppm) for long fibers (>5 µm).	Good all-around technique for full asbestos identification.	Cannot resolve individual fibrils that may be present in ground product.
Scanning electron microscopy (**SEM**)	Uses chemistry and macro-morphological factors for identification of asbestos.	**Long fibers only** (length >5µm; width >0.25 µm)	<0.01% (<100 ppm) for long fibers (>5 µm).	Alternative to PLM with greater resolution.	Conventional SEM cannot resolve individual fibrils; chemical interferences exist (i.e. talc/anthophyllite).
Transmission electron microscopy (**TEM**)	Uses chemistry, electron diffraction, and micro-morphological factors for identification of asbestos.	**Short and long fibers** (length >0.5 µm; width >0.025 µm); very long fibers not included in prep.	<0.0001% (1 ppm) for short and long fibers >0.5 µm.	Best method for phase ID; most sensitive; only technique for the fine size range.	Cannot distinguish asbestiform from cleavage fragment with similar aspect ratio for fine size range (fibrils do not display macro-morphological features).

STATEMENT

Our products do not contain asbestos as defined by US Occupational Safety and Health Administration and European Directive 83/477/EEC, when analyzed by conventional methods. We utilise independent certified laboratories for verification."