

Clayton Environmental Consultants, Inc.**ASBESTOS: THE PROBLEM AND ITS CONTROL****1.0 INTRODUCTION**

Asbestos is a generic term used to describe a number of naturally occurring fibrous hydrated mineral silicates. These have been divided into two mineral groups: pyroxenes and amphiboles. Commercially, the most important form of asbestos is chrysotile, a pyroxene which accounts for more than 95% of domestic consumption. Commercially important amphiboles are crocidolite, amosite, and anthophyllite. Of lesser commercial importance are two other amphiboles: tremolite and actinolite.

Asbestos has been known and used throughout history, but did not become important commercially until about 100 years ago, following the discovery of large chrysotile deposits in Quebec and Russia.

Asbestos is widely used today. One study has estimated that asbestos is contained in over 3,000 products. This widespread use of asbestos is due to its relatively low cost and its unique combination of strength, flexibility, incombustibility, thermal and electrical resistance, frictional properties, and resistance to corrosion. The strength, insulating, and fire-resistant properties of asbestos result in many construction industry applications, where approximately 75% of all asbestos is used.

A growing awareness of the harmful properties of asbestos has resulted in a restriction of its use by the Environmental Protection Agency (EPA) in certain applications, e.g., asbestos cement for boiler insulation and asbestos sprays for fireproofing and insulating. However, even where substitute materials have been used, the existence of asbestos in older installations will continue to pose an occupational hazard for repair workers for many years.

History of Health Effects

It has been known since the early part of this century that workers who inhaled large amounts of asbestos dust sometimes developed a disabling or fatal fibrosis of the lungs. This condition has come to be called asbestosis or asbestotic pneumoconiosis. Early studies of asbestosis in Great Britain led to the adoption by that country in 1932 of regulations

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limiting occupational exposure to asbestos dust. In the United States, asbestosis cases were first reported in 1930 and dust control guidelines were first proposed in 1938.

Asbestos exposure was first linked to bronchogenic carcinoma (lung cancer) in 1935, but it was not until 1947 that epidemiological evidence of a causal connection was established. Since then, numerous studies have confirmed an association between occupational exposure to asbestos and significantly elevated rates of bronchogenic cancer.

The first link between asbestos and pleural mesothelioma (a rare and invariably fatal cancer of the chest cavity lining) was reported in 1943. A strong association was not established until 1960 when a study in a crocidolite mining area of South Africa found that 31 of 33 persons with pleural mesothelioma had experienced some asbestos exposure. Additional evidence of a causal relationship between asbestos and pleural mesothelioma has since accumulated and asbestos has similarly been implicated as a cause of peritoneal mesothelioma (a very rare and fatal cancer of the abdominal lining).

Current and Proposed OSHA Standards

The original OSHA standard for exposure to asbestos was published on May 29, 1971. It established an exposure limit of 12 fibers (greater than 5 microns in length) per milliliter of air, or 2 million particles per cubic foot of air.

On November 4, 1971, the original OSHA standard was challenged and the Secretary of Labor promulgated an emergency temporary standard for occupational exposure to asbestos dust on December 7, 1971. The emergency standard stated that "the 8-hour, time-weighted average (TWA) airborne concentration of asbestos dust to which employees are exposed shall not exceed 5 fibers (greater than 5 microns in length) per milliliter of air. Concentrations above 5 fibers per milliliter but not to exceed 10 fibers per milliliter may be permitted up to a total of 15 minutes in an hour for up to 5 hours in an 8-hour day."

A new permanent asbestos standard was first proposed on January 12, 1972, and promulgated on June 7, 1972. This standard is the existing standard. It followed the emergency standard and established an

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8-hour, TWA exposure limit of 5 fibers (longer than 5 microns) per cubic centimeter of air and a ceiling limit against any exposure in excess of 10 such fibers per cubic centimeter of air. Effective July 1, 1976, the 8-hour, TWA was reduced from five to two fibers. This standard also includes provisions for additional engineering and administrative controls, work practices, and procedures for medical surveillance and monitoring. Medical surveillance is required whenever workers are exposed to "measurable" asbestos concentrations. In October 1975, OSHA proposed a reduction in the permissible limit for asbestos exposure to 0.5 fibers/cc for an 8-hour, TWA exposure (fibers $>5 \mu\text{m}$ in length). The proposal also included a corresponding reduction in the ceiling exposure limit from 10 to five fibers/cc as determined over a period of up to 15 minutes.

In December 1976, the National Institute for Occupational Safety and Health (NIOSH) recommended to OSHA that no worker be exposed to airborne concentrations of asbestos in excess of 0.1 fibers/cc on an 8-hour, TWA basis and further, that no worker be exposed to peak concentrations in excess of 0.5 fibers/cc based on 15-minute sampling periods.

EPA Standards

The U.S. Environmental Protection Agency (EPA) National Emission Standard for Asbestos (40 CFR 61, Subpart B) requires that any renovation or demolition work involving friable asbestos materials be reported in writing to the EPA prior to such activity. This standard also requires that certain procedures be followed for the removal of asbestos prior to demolition, including procedures for wetting, ventilation, warning signs, and disposal.

Other Standards

In addition to the federal OSHA and EPA standards for asbestos, there are other, less commonly known regulations which may have to be considered. For instance, the state of California requires that any activities in which materials containing more than 1% asbestos (dry weight) are disturbed must be reported. It also outlines procedures for engineering controls, work practices, protective clothing and respiratory protective equipment, monitoring, record-keeping, medical surveillance, and employee information and training.

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2.0 SAMPLING AND ANALYTICAL METHODS

Bulk sample asbestos analyses are performed by X-ray diffractometry. Initially, the sample material is ground in a ball mill. One hundred mg of the ground sample is suspended in a 0.05% solution of Triton X-100 in water. A 50 mL aliquot (5 mg of sample) is deposited on a Nuclepore filter which is scanned by X-ray diffraction. The diffraction scan of the sample is compared with scans of standards of the various asbestos forms which have been similarly prepared. Detectable levels of asbestos are quantitated. The detection limit depends upon the type of asbestos found in a particular sample. Each of the six asbestiform minerals (chrysotile, amosite, crocidolite, tremolite, actinolite, and anthophyllite) is determined individually, as each exhibits different diffraction peaks.

Air Samples

Samples are collected by drawing air through a cellulose-ester membrane filter with a battery-powered personal sampling pump. After sampling, the filter is transformed from an opaque, solid membrane to a transparent, optically homogenous gel. The fibers are sized and counted by phase-contrast microscopy at 400 to 450X magnification.

This method considers only fibers with a length-to-width ratio of 3 to 1 or greater, and a length greater than 5 microns. Thus, it is intended to give an index of exposure to airborne asbestos fibers of specific, yet limited, dimensional characteristics.

The method has been successfully applied using 37-mm Millipore AA filters and small battery-operated personal sampling pumps at flowrates of 1.0 to 2.0 liters per minute (Lpm) over a concentration range of 1 to 20 fibers/cc. Large deviations from these conditions can result in samples with either too few or too many fibers, which can yield air concentration estimates of low statistical precision and accuracy.

Sources of Error and Measures of Precision

The relative variation or dispersion of a normally distributed data set (such as the random variations in a sampling and analytical procedure) is commonly measured by the "coefficient of variation" (CV). The CV is also known as the relative standard deviation.

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It is calculated by dividing the standard deviation of the data by the arithmetic average. The CV is a useful parameter of dispersion in that limits consisting of the true mean of a data set, plus or minus 1.645 the standard deviation, will contain about 90% of the data measurements. This is a rough approximation that depends on the number of data values from which the mean and standard deviation were calculated. Correspondingly, if an analytical procedure with a known CV of 0.24* were used to measure repeatedly some fixed physical property, then about 95% of the measurements would fall within plus or minus 48% (twice the CV) of the true concentration, assuming an unbiased measuring procedure.

Confirmatory Analytical Techniques

Polarized Light Microscopy - is one of the most effective techniques for the identification of asbestos. This method depends on the unique optical crystallographic properties (refractive indices, birefringence, sign of elongation, and extinction) of the various crystal phases in the sample.

Dispersion Staining - It has been proposed that the outer $Mg(OH)_2$ surface of the asbestos fibers might be stained with a selective dye after sample collection and the asbestos then be estimated by spectrophotometry, or alternatively, be more easily counted optically because of the enhanced contrast.

Electron Microscopy - has great advantages over light microscopy in terms of higher resolution. This permits derivation of morphological information which can be used for positive identification of asbestos. For instance, chrysotile fibers exhibit characteristic center channels, and most asbestos fibers break so that the ends are fairly characteristic. However, these effects are not sufficiently specific to provide positive identification in all cases, making additional characterization necessary. This may include X-ray fluorescence and selected area electron diffraction techniques.

In scanning electron microscopy (SEM), filters are first vacuum-coated to make them conductive. The

*NIOSH estimate of CV for asbestos measurements

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frequency of fibers that display X-ray fluorescence characteristic of asbestos are then measured against standards.

The Transmission Electron Microscope (TEM) - coupled with selected area electron diffraction (SAED) represents a powerful analytical tool for asbestos determination. In cases where diameters of the fibers can vary over a wide range, SEM is preferable. The TEM is unable to cope satisfactorily with a wide range of diameters.

Although electron microscopy offers the advantage of achieving positive, accurate identification of any crystalline fiber by its electron diffraction pattern, with good sensitivity, the analysis time is relatively long. Processing time typically exceeds 4 hours per sample. The required instrumentation is also prohibitively costly for widespread, routine use.