A Brief History of Asbestos Dust Measurements and Limits

by

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In the 1920's it was recognized that workers for significant periods of time in mining and certain dusty manufacturing industries developed lung diseases that were disabling and ultimately fatal. The probability of disease increased with the degree of dustiness, the years worked, and the percentage of free silica (usually quartz). Control was necessary . To evaluate the hazard and effectiveness of controls some measurement method was necessary. A simple dust concentration by weight was not suitable because most of the weight of the dust would be contributed by particles too large to enter the lung. The number concentration of dust between 1 and 10 micrometers (μm) in diameter appeared to be a suitable index of hazard.

The Greenberg-Smith Impinger

In 1925 Greenberg and Smith developed a simple device they called the impinger. In the impinger a jet of air was drawn through a nozzle into water and impinged on a glass surface. The dust particles were thrown out by centrifugal force and became suspended in the liquid. The sampling rate was one cubic foot per minute, and the liquid volume was 100 cubic centimeters (cc). Samples were typically taken for five or ten minutes. The liquid was then diluted to a known volume and a small quantity placed in a 1 mm deep glass cell. After allowing the particles to settle for half an hour the cell was placed on a microscope stage and counted with 100 times magnification. In the barrel of the microscope was a grid called a Whipple disc that delineated a 1 millimeter square field. Usually 1/4 of the field, divided into 25 squares was counted. Knowing

the volume of air sampled, the volume of liquid counted, the dilution, and the number of particles counted, a concentration was calculated in millions of particles per cubic foot (mppcf). It was this Greenberg-Smith impinger that was used by the U. S. Public Health Service in its studies of the dusty trades during the 1930's. At the time silicosis was a major occupational health hazard and their studies were primarily of silica-containing dusts that were causing silicosis in exposed workers.

The Public Health Service Asbestos Study of 1938

When, as part of the dusty trades studies, the U.S. Public Health Service's Division of Industrial Hygiene, in cooperation with the North Carolina State Health Department, performed a study of four North Carolina asbestos textile mills, the standard impinger method was used.. Although the investigators recognized that it was the microscopic fibers that caused asbestosis, few fibers were seen in the impinger samples. Therefore, the ordinary dust particles that accompanied the asbestos fibers were used as an index of the health hazard, with the concentration reported as mppcf. The conclusion of this study was that if time-weighted average dust counts were kept below 5 mppcf, new cases of asbestosis were unlikely to develop. This limit of 5 mppcf for asbestos was used from 1938 on by industrial hygienists measuring asbestos-containing dusts.

No guidance was given for measuring dust from products that were only partially asbestos. For example, a thermal insulation product that consisted of ten to fifteen per cent asbestos could be given a suggested limit of 20 mppcf by one industrial hygienist, 10 mppcf by another industrial hygienist while a third used 5 mppcf since it was called asbestos insulation.

The textile mills processed no mineral other than chrysotile asbestos (60-95 %); the balance of their yarn and cloth was cotton or rayon.. Two other types of asbestos with different chemical composition and physical properties were also used commercially. The second was amosite, used in some thermal insulation and specified in naval construction. The third type was crocidolite which was used extensively in Great Britain. In the U.S. it was used primarily in some asbestos cement pressure pipe. It was also used in graphite-asbestos faucet packing and in products where acid resistance was required. A fourth type, tremolite, was present in traces to small percentages in some chrysotile deposits. Amosite, crocidolite, and tremolite were of the amphibole family. In general, these fibers were straighter and stiffer than chrysotile.

The Midget Impinger

The pump necessary to draw one cubic foot per minute through the Greenberg-Smith impinger at 3" of mercury required either an AC source or a compressed air ejector. This limited its use in measuring work exposure. In the 1940's the U.S. Bureau of Mines developed the midget impinger. The principle of operation was the same, but it sampled at 0.1 cfm into 10 cc of water in a small glass flask. The vacuum was 12 inches of water. This vacuum was obtained by a four cylinder hand cranked pump carried on a shoulder strap. The midget impinger almost immediately replaced the large impinger and enabled collection of breathing zone samples in virtually any location. The samples were counted in the same manner as before. The impinger method remained the standard for asbestos sampling until 1968.

The Membrane Filter Method

In the 1950's a new sampling medium, the membrane filter, became available. The

membrane filter collected particles of any size on the surface. The impinger, so suitable for the hazardous quartz dust, was found to be inefficient for the microscopic chrysotile asbestos fibers. The membrane filter could be rendered transparent after sampling by the application of readily available chemicals, making it suitable for microscopy. Because the particles collected were on the surface, not more than a millimeter away, a higher powered microscopic objective could be used. Now fibers invisible at 100 times magnification could be counted directly with a magnification of 400 to 450 times. Also in the 1950's small battery powered pumps became available that could sample for hours at two liters per minute. The membrane filters came in plastic cassettes of 37 mm or 1 inch diameter. At the dust concentrations of typical asbestos product manufacturing, a one to two hour sample at two liters per minute would produce a countable filter. In the mid 1960's the PHS Division of Occupational Health (now the National Institute for Occupational Safety and Health (NIOSH) performed a study of asbestos product manufacturing facilities. Simultaneous impinger and membrane filter samples showed that on average 1 mppcf was equivalent to 6 fibers per cc..

Changing Perceptions

Until the 1960's concern about asbestosis was limited to those industries using raw asbestos to manufacture asbestos containing products. Further, although the 1938 U.S. Public Health Service report had references to lung cancer occurring as a complication of asbestosis, the concerns remained prevention of asbestosis. Presumably if asbestosis were prevented, other adverse health consequences would also be prevented. In about 1962 Dr. Christopher Wagner reported cases of mesothelioma, a cancer of the peritoneum or pleura, among crocidolite miners

and millers in South Africa. But in the early 1960's Dr. Irving Selikoff conducted a mortality study of union insulators in the New York, New Jersey area. He reported his results in a conference organized by the New York Academy of Sciences in 1964. At this conference he reported asbestosis and excesses of lung cancer among the insulation workers. Furthermore, there were cases of mesothelioma,. Measuring the exposure of insulators in the construction trade to asbestos proved extraordinarily difficult. Unlike manufacturing workers the insulators performed different tasks in different places with a variety of products, no more than a few at any one location. An exception to this was a study of insulators by Philip Drinker and associates in shipbuilding during World War II. They concluded that insulating was not a hazardous trade, but recommended that dust counts be kept below 5 mppcf as a matter of good practice. Although the 1964 conference showed excesses of disease the only measurement of exposure was years in the trade. Other papers presented at the conference by scientists from around the world also showed excesses of asbestosis and lung cancer, but again without measurements of dust counts. Thus the TLV committee had no data on which to base a reduction of the TLV's until the 1968 report from the Pennsylvania Health department.

Limits for Asbestos Dust in Air

Based on the 1938 USPHS study, a threshold limit value (TLV) of 5 mppcf was adopted by the American Conference of Governmental Industrial Hygienists (ACGIH) as part of their first threshold limit value (TLV) list in 1946. This TLV was the accepted limit until 1968 when the Pennsylvania State Health Department reported that cases of asbestosis were occurring at less than 5 mppcf. The TLV was then reduced to 2 mppcf with an alternative of 12 fibers per cc by

the membrane filter method. This 12 fiber per cc limit was adopted by the Department of Labor and included in the first OSHA Permissible Exposure Limit (PEL) list in 1971. In their first full standard, for asbestos in 1972, OSHA set a limit of 5 f/cc immediately, with a phased reduction to 2 f/cc in 1976. This 2 f/cc limit was maintained until it was reduced to 0.2 f/cc in 1986.

Independently, the ACGIH TLV committee in 1970 proposed a change in the TLV to 5 fibers per ml (f/ml) not longer than 5 micrometers (μm) in length. In 1973 they stated that "A more stringent TLV for crocidolite may be required ". In 1978 they proposed limits as follows: amosite 0.5 f/cc, A1a ; chrysotile 2 f/cc, A1a; crocidolite 0.2 f/cc, A1a; tremolite 0.5 f/cc, A1a; other forms 2 f/cc, A1a. (A1a was a footnote indicating that the material was a carcinogen). In 1991 they proposed asbestos, all forms 0.2 f/cc and in 1997 asbestos all forms 0.1 f/cc. The TLV from 1998 to the present remains 0.1f/cc.