

PRESENT THRESHOLD LIMIT VALUE IN THE U.S.A.
FOR ASBESTOS DUST: A CRITIQUE

E. L. Schall

Occupational Health Program, New Jersey State Department of Health
Trenton, N. J.

The present threshold limit value for asbestos dust in the U.S.A. is 5.0 millions of particles per cubic foot of air for a daily eight-hour exposure, 40 hours per week. This value was adopted many years ago by the American Conference of Governmental Industrial Hygienists and reaffirmed at the annual meeting in April, 1964.¹ It refers to airborne concentrations of asbestos dust which represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse affect. However, threshold limits should be used as guides in the control of health hazards and should not be regarded as fine lines between safe and dangerous concentrations. These limits are based on the best available information from industrial experience, from experimental human and animal studies, and when possible, from a combination of the three.

Referring to the *Documentation of Threshold Limit Values* published by the American Conference of Governmental Industrial Hygienists¹ we learn that the basis for the threshold limit value of five mppcf for asbestos dust results from studies conducted by Miller and Sayers which showed that intraperitoneal injection of amosite, chrysotile and crocidolite in guinea pigs produced the reaction of an inert dust.² Vorwald, Durkan, and Pratt confirmed this for short fibers (under three microns) but observed that long fibers produced a fibrous reaction.³ Continuing unpublished work by Gardner, these workers demonstrated that long fibers (20 microns and above) produced peribronchiolar fibrosis in lower animals, and developed evidence that this resulted from mechanical rather than chemical action.

That exposure to asbestos is associated with development of a potentially disabling pneumoconiosis in man has been amply demonstrated by industrial experience. The present threshold limit relates to the prevention of asbestosis. It was recommended by Dreessen, DallaValle, Edwards, Miller and Sayers² after study of 541 employees in three asbestos textile plants using chrysotile. Only three doubtful cases of pneumoconiosis were found in those exposed to dust concentrations under five mppcf, whereas numerous well-marked cases were found above five mppcf. Counts were from impinger-collected samples in ethyl alcohol and distilled water. Both fibrous and nonfibrous particles were counted, but the latter greatly predominated. While chemical analyses of collected samples of airborne dust corresponded to those of settled dust samples, it is believed that dust counts of particulates by conventional methods can be expected to give only an indirect

measure of the risk of asbestosis because of the great relative importance of long fibers.

When considering the value of five mppcf resulting from this study, it is pertinent to remember that *A Study of Asbestosis in the Asbestos Textile Industry* was published in August 1938. The study was limited from the beginning to the disease asbestosis and no consideration appeared to be given to other possible diseases which may result from exposure to asbestos dust excepting possible complicating tuberculosis.

The study was limited to textile plants only. At the present time asbestos is used in many other industries. The utilization of asbestos in this type of plant has no necessary relationship to its use otherwise since different grades, sizes and varieties might be used. Different types of exhaust ventilation systems possibly served other kinds of machinery under varying environmental conditions than was found to exist in the textile plants at the time of the study. It should be noted, too, that textile plants tend to use chrysotile only since this fiber is much more suitable for textile purposes. That was true in this study since on page 19, footnote 2 states "Canadian Asbestos (chrysotile), the asbestos used in these factories. . . ." Again on page 3 is the statement that "Approximately 90 per cent of the asbestos used in these plants is obtained from Canada. The remaining 10 per cent comes from Arizona or South Africa, and, infrequently, from Russian and Australian sources."

In textile work there is a tendency to use cleaner fibers and more flexible fibers as well as longer ones.

The asbestos textile industry studied by Dreessen *et al.* was entirely American. This does not allow conclusions to be drawn with regard to other textile plants. Page 15 states that "British practice differs in many respects from American practice. The same type of machinery is used in both countries but in British factories, dust-control equipment seems to be more generally used than in American factories. British factories specialize in the production of fine yarn and this involves numerous differences in practice." If the textile plants in this country were to produce finer yarn today, we would expect that the practices would differ from those in British factories. When a batch of asbestos fibers consisting of various blends is made, it must be mixed with cotton before it can be spun and woven. Page 7 states "As a rule, from 5 to 15 per cent by weight of all the asbestos textiles produced in this country is cotton." Page 43 states "No distinction could be made between cotton and asbestos fibers."

It is believed that an ordinary microscope provided with a suitable eyepiece and objective and fitted with an Abbe condenser, and properly calibrated was employed to count dust particles using the light-field technique as mentioned in the bibliography on page 118 number 2 (Bloomfield and Dalla Valle, *The Determination and Control of Industrial Dust*). The

there was no separation of the type of particles studied so that stone dust, cotton dust and other particles were counted. No count was made of very small particles beyond the resolving power of the optical microscope or of such particles which now can be seen using a Kohler light source instead of the ordinary small electric microscope lamp.

There are considerable difficulties in separating each process even within the textile plant. Such difficulties are compounded by the contiguity of different operations, the particular type of activity of the plant at the time of sampling, one loom or many, etc. On page 26 it is noted that counts may vary even with one operation, with the different speeds of the machine (page 27), with the grade of material used (page 28), the nature of weaving requirements (page 28) and with wet or dry weaving (page 29). The counts may vary with the end product (page 29). It should also be noted that the counts were made against a constant background count (page 30). We now know that this cannot be ignored since cases both of asbestosis and neoplasia associated with asbestosis have been recorded following the minimal exposure of community environment.

Variations in the nature of the dust were not considered. This may have played a significant role in this study. For example, of the four plants investigated, two converted crude asbestos into yarn and woven goods while the other two purchased yarn and ended with finished goods (pages 3-4). The size of the plants varied and the size and number of processes usually make a difference in environmental conditions found. Two were large and two were small (page 16-17). The number of employees varied from 32 in the smallest to 281 in the largest. Tables 2 and 3 on page 20 and figures 13 and 14 on pages 21 and 22 show that while the chemical composition of the dust did not vary, the gross appearance did in each of the occupations. However, this variance was not allowed for and all dusts were lumped together. Figures 13 and 14 also show that the dusts at each occupation were different. Pages 22, 23, 43 and 60 showed differences in the proportion of fibers to particulate matter in the dust. Presumably much of the particulate matter was serpentine rock dust which has been reported to be innocuous. It is also known that the rock dust in the Canadian chrysotile area has a very low silica content which would correspond with the innocuous nature of serpentine dust. Inasmuch as chrysotile is now being supplied much cleaner, with a consequent change in the per cent of particles and fibers in any dust derived from it, the same count might now have different meaning.

It is not commonly appreciated that the five mppcf indicates a total count, including background dust which may vary greatly including cotton, rock dust, asbestos fibers, etc. On page 23 is stated "The measurement of dust particles suspended in the air of asbestos textile plants is difficult because of the presence of both asbestos and cotton fibers. The differentia-

tion of these fibers under the microscope is not always possible, especially when the fibers are short and fine. Several samples obtained with the Owens jet apparatus were examined with a petrographic microscope in order to estimate the proportion of asbestos and cotton fibers, but no satisfactory technique could be developed for this purpose."

Table 4 on page 23 demonstrates that very few fibers were encountered in the samples collected. One to eight per cent were observed in crushing, twisting, carding, and picking operations, while 12 per cent in one plant, 26 per cent in another were present in weaving operations. A biological phenomenon might have relevance here; there is frequently a differential retention which varies with the concentration of the inhaled material. Thus, if many fibers were inhaled and only a certain per cent retained, there is no insurance that with a small number of fibers inhaled only a small per cent will be similarly retained — it may be very much more.

At the time of the study, correlation was made with disease and dust counts observed, with exposure presumed to have taken place 5 to 15 years before. In two of the three plants there had been no major change and presumably the dust counts were unchanged from the onset of exposure. However, in one plant exposure was probably higher at the time of the examination because of plant expansion than when men were being exposed. Page 32 states "Hence, it may be assumed that the exposures of all occupations in plant B following carding were probably higher during the study than prior to expansion." About 15 months before this study was begun, approximately 150 workers in these asbestos textile factories were replaced by workers with little or no previous asbestos exposure (page 46). Although an effort was made to examine as many as possible of these former workers, a majority could not be examined. Partly as a result of these personnel changes, the group of employees examined in this study had an unusually low average age. There was an abnormally large percentage of workers with less than five years' employment in the asbestos textile industry and an abnormally small percentage of persons who had worked 10 years or more in this industry. On page 47 we read "The average age of white male industrial workers is less in the asbestos textile factories studied than it is in 14 other industries in which the Public Health Service has made similar studies." The book *Silicosis and Asbestosis* by Lanza⁵ states on page 173 "In some roentgenograms of asbestos factory workers seen with Dr. Lanza, we noted that there was a direct progression into a terminal diffuse fibrosis without any nodular predominance. This terminal state seemed to have been reached in about 20 years on the average." On page 186 we find "Merewether and Price state that, with continued exposure to high concentration dust, fibrosis may be fully developed in from seven to nine years, and that death may result in about 13 years. With less concentration, fibrosis may not be fully developed for 15, 20, or 25 years." Yet,

in this study 333 of 511 employees have worked for less than five years! Only 66 of 511 had worked for more than 10 years. Seventy-three of 511 actually were employed for less than one year (page 47). Moreover, of the 511 studied, 76 were "controls" which consisted of 49 office workers and other employees "not exposed to asbestos dust" and 27 persons seeking employment in the asbestos industry for the first time (page 48). It should be noted that these were not true controls since on page 42 it is learned that even in these areas atmospheric dust concentrations ranged from 120,000 to 1,200,000. We now know that the effect of the environment is potentially very important. In Wagner's studies in South Africa most of the mesotheliomas occurred in association with environmental asbestos exposure and not in an industrial exposure. Controls should have been sought in an area in which asbestos was not present at all. Thus, the baseline eight per cent cough and seven per cent dyspnea may be at least partly significant (page 52) and the findings with less than 25 million-particle-years of 14 per cent cough and 12 per cent dyspnea may have greater significance.

It is important to stress that the five mppcf value is based upon dust counts of all particles, fibrous and particulate, asbestos or not. Therefore, it cannot be presumed to represent a safe limit of asbestos in all applications.

The dust counts given were average. Yet the range was enormous and there is much biological evidence to indicate that peak exposures may be more important than constant overall background exposure since on these occasions the defense mechanisms of the lungs may be overwhelmed with huge retention at these particular times. Pickermen are listed in table 8 as being exposed to from 34.3 to 74.3 mppcf. However, during certain phases of their operations dust concentrations may range as high as 211 mppcf (page 26). In carding, for example, the exposure is listed in table 9 as 29.1 mppcf but when the machines are run slowly, concentrations were as low as 6.4 mppcf and when operated at high speed, the concentration reached 139 mppcf. Similar statistics are available for other operations. Twisting frequently produced concentrations of over 20 mppcf and when low grade materials are used, the dust production is increased. Even the low counts associated sometimes with weaving must be accepted guardedly since proportionately there were more and longer fibers. Table 12 indicated counts of 4.7 mppcf, yet the dust created depended on many factors including the number of warp threads per unit of width, quality of material used, whether or not dry weaving was used, etc. In some weaving operations, counts of more than 140 mppcf were found. Although dry and wet weaving gave different results (table 12), operators were interchangeable and the machines were often side by side. Counts also varied when all looms in a room were used or not, since the room size and exhaust ventilation were constant. What was woven also make a difference, brake lining wear-

ers appeared to have lower exposures than broadcloth weavers but when heavy brake linings were woven, the counts again went up (page 29).

Medical data in the study suffered from several unavoidable difficulties. More than one-half of the male and female employees were under 30 years of age (page 47). As previously stated, this group had the lowest average age of any group studied by the Public Health Service. Table 22 states that the average age for the asbestos textile industry was 32.1 as compared with the post office and foundry industry of 37.8 and 33.1 for the rubber and chemical industries. One of the reasons, perhaps, for this was the fact that the asbestos textile industry was "of comparatively recent origin in this country. Only one of the plants studied had been in operation before 1920" (page 48).

This was a "point survey" of people at work with all the epidemiological difficulties it entails. In a survey of this type, the sick are missing and the dead are buried. Because of the relatively small number of individuals examined in each group, the percentage values as given "must be viewed with caution because they are based on small numbers of workers. This is particularly true in the groups with more than 10 years' employment," (page 58).

Finally, note should be made that Dreessen and his colleagues regarded the figure they gave of 5 mppcf as simply a working figure for that time. On the basis of their studies, they concluded that "5 million particles per cubic foot may be regarded tentatively as the threshold value for asbestos-dust exposure until better data are available" (page 91).

References

1. AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS. 1964. Threshold Limit Values for 1964. American Conference of Governmental Industrial Hygienists. Cincinnati, Ohio.
2. DREESSEN, W. C., J. M. DALLAVALLE, T. I. EDWARDS, J. W. MILLER, R. R. SAYERS, H. F. EASOM & M. F. TRICE. 1938. A study of asbestosis in the asbestos textile industry. Public Health Bull. No. 241. Washington, D.C.
3. VORWALD, A. J., T. M. DURKAN & P. C. PRATT. 1951. Experimental studies of asbestosis. A.M.A. Arch. Indust. Hyg. Occup. Med. 3: 1-43.
4. BLOOMFIELD, J. J. & J. M. DALLAVALLE. 1935. The determination and control of industrial dust. Public Health Bull. No. 217. Washington, D.C.
5. LANZA, A. J., Ed. 1938. Silicosis and Asbestosis. Oxford Univ. Press. London, England.
6. WAGNER, J. D., C. A. SLEGGES & P. MARCHAND. 1960. Diffuse pleural mesothelioma and asbestos exposure in North Western Cape Province. Brit. J. Indust. Med. 17: 260-271.