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THE ORIGIN AND DEVELOPMENT OF THE ASBESTOS THRESHOLD LIMIT VALUE: SCIENTIFIC INDIFFERENCE AND CORPORATE INFLUENCE

David S. Egilman and Alexander A. Reinert

Several recent articles have critiqued the process employed by the American Conference of Governmental Industrial Hygienists in determining Threshold Limit Values. Criticisms have included inadequate data collection, inadequate research, excessive corporate influence, and slow response to informational changes. In this article, the authors address the historical development of the American Conference of Governmental Industrial Hygienists' asbestos exposure guideline. They demonstrate that the proposed guideline was known to be inadequate when it was first proposed, was severely criticized between 1946 and 1968, but nonetheless was promulgated annually and remained unchanged until 1971.

The American Conference of Governmental Industrial Hygienists (ACGIH) sets guidelines for occupational health called Threshold Limit Values (TLVs). These guidelines are relied on by OSHA (the Occupational Safety and Health Administration) in the United States and similar agencies around the world. Past criticisms of the guideline-setting process have pointed to problems with data collection, inadequate research, overwhelming dependence on data supplied by financially interested corporations, and slow response to advances in medical information (1, 2). An examination of the guideline-setting procedure for one occupational hazard in particular, asbestos exposure, reveals three factors that have influenced the determination of many other ACGIH guidelines: (*a*) ACGIH failed to analyze previously published literature, or review and incorporate current literature (inadequate research); (*b*) ACGIH uncritically accepted unpublished research data from financially interested companies (poor judgment); (*c*) financially interested companies (asbestos manufacturing and mining companies and their insurers) modified medical articles to minimize concern over asbestos health

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effects and create a controversy concerning the relationship between asbestos and cancer, and suppressed other internal studies that indicated that the guideline failed to protect workers from asbestosis or cancer (corporate corruption).

These three factors contributed to the asbestos guideline's remaining unchanged from 1946 to 1971, despite overwhelming evidence of inadequacy (3). The combination of inadequate research, poor judgment, and corporate corruption resulted in harmful exposures of asbestos to millions of workers worldwide. Other ACGIH guidelines have problems similar to those of the asbestos guideline, and persist. We raise the asbestos example in order to point to ACGIH's general indifference and lack of accountability, which has resulted and will result in the publication of numerous guidelines that may ultimately fail to protect the public from health hazards.

Our first concern in this article is to provide a general history of knowledge of the properties and health effects of asbestos in the United States. We will then consider the origin and development of the asbestos guideline and investigate how that guideline was interpreted and used in the scientific and corporate community. After examining these issues, we will consider the ACGIH TLV Committee's institutional indifference to guideline-setting as exemplified by their failure to adequately assess the financially motivated scientific comments of asbestos corporations, their insurers and medical consultants, and their limited review process. Finally, we will explore the asbestos corporations' influence on and application of the asbestos guideline.

Throughout this article, the use of the terms "Threshold Limit Value (TLV)" and "Maximum Allowable Concentration (MAC)" may become confusing. In an effort to ensure better understanding of these terms, we will use the word "guideline" to describe any value used to predict sickness in humans. Guidelines have been published annually by ACGIH from 1946 to 1991. Exposures to toxic substances at levels above the guidelines were considered hazardous. Guidelines promulgated by ACGIH from 1946 to 1948 were called Maximum Allowable Concentrations. A Maximum Allowable Concentration is a level that should not be exceeded. In 1948, ACGIH renamed the guidelines "Threshold Limit Values," but did not change the definition of the guidelines for 5 years. In 1953, the ACGIH defined a TLV as an average and a maximum level that should not be exceeded. Different definitions imply different total exposure to toxic substances, as seen in Figure 1.

ASBESTOS: PHYSICAL PROPERTIES

Asbestos is heat-resistant and also has binding properties that make it ideal for use in a multitude of industries ranging from textiles to insulation materials. Asbestos is defined both by its physical characteristics (it is a fiber) and by its chemical composition (it is a silicate). A silicate is a mineral comprised of a combination of silica, oxygen, and magnesium or iron. Before asbestos was

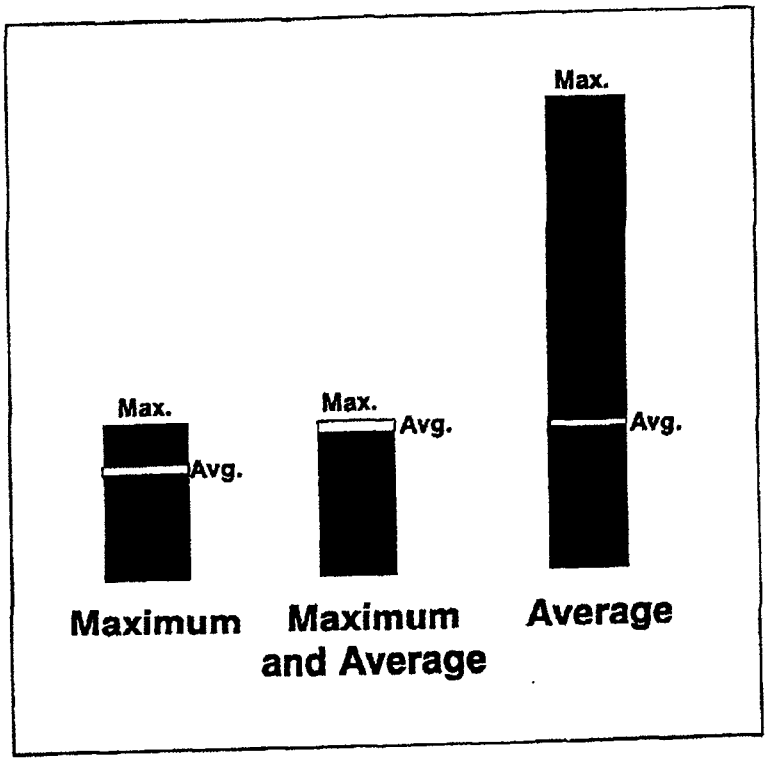

Figure 1. Different definitions of the Threshold Limit Value imply different total exposures.

widely identified as a disease-causing dust, exposure to silica dust was recognized as the cause of a respiratory disease that became known as silicosis. The fibrous nature of asbestos is the physical characteristic that distinguishes asbestos from silica.

In evaluating the guideline applied to asbestos exposure, it is important to consider the distinction between the fibrous morphology of asbestos and the nonfibrous nature of other dusts. For example, silica dust is comprised of particles that, when viewed under a microscope, resemble dots. Asbestos dust, on the other hand, is made up of particles and fibers, elongated particles with parallel edges and apparently equidimensional cross-sections (4). Fibers, as a subset of particles, are defined by some as particles with a length three times greater than their width (5).

In addition, notwithstanding its fibrous nature, asbestos can never be found as pure fiber. Where it is mined, it is mixed with dirt, rocks, and grit, which microscopically are particles. Even though the process of carding and purifying asbestos removes much of the foreign particles, asbestos itself can chip and flake and produce particles. Because of this, even 100 percent fibrous asbestos (for example, in asbestos cloth) will, if ripped, torn, or cut, produce other particles in addition to fibers. Therefore, any time asbestos is used, even in relatively pure fibrous form, there are exposures to both fibers and particles. This can confound attempts to measure exposure.

Even when asbestos exposure is assessed by a measurement of fibers instead of all particles (which includes both particles and fibers), the process is complicated by the physical propensity of asbestos to fracture longitudinally, causing a single fiber to produce many fibers; this division can occur in the lung after inhalation (6). The process of in vivo breakdown has not been well studied either in animals or in humans. It further obscures the assessment of exposures even when fibers themselves are measured.

HEALTH EFFECTS

In a case study reported in 1907, Montague Murray was the first to note the adverse health effects related to working with asbestos (7). Originally labeled "asbestos poisoning" and later termed "asbestosis," the symptoms associated with the disease included dyspnea, cough, emaciation, weakness, and chest pain. Cooke (8) and McDonald (9) were the first to describe "curious bodies" in the lungs of individuals who had died of asbestosis; these bodies were later called "asbestosis bodies."

Because the disease asbestosis was identified soon after the United States had begun to grapple with silicosis, analogies were drawn between the two diseases. Clinically, asbestosis is a much more serious disease: it has a shorter time of onset, the symptoms are more severe, and the average life span of an asbestotic is much shorter than that of the average worker who dies from silicosis (10–14). X-ray changes in silicosis are much more dramatic than those in asbestosis. Clinically, however, an asbestotic with less marked X-ray abnormalities may be more severely disabled (15–17).

Mechanism of Disease Production

In the 1920s and early 1930s, Leroy Gardner, the director of the Saranac Laboratory, conducted experiments to explain the health effects of asbestos (18, 19). Gardner's experiments were designed to determine whether the chemical composition of the asbestos or its fibrous nature was the cause of the harmful effects of inhaling asbestos-containing dust. Gardner's studies were funded by a group of asbestos companies who maintained control of the content of the final

publication (1). He exposed animals to combinations of asbestos fibers of different lengths, and to particles. To test the effects of pure silicate chemical exposure, animals were exposed to ground asbestos (ball-milled asbestos), composed almost entirely of particles. The purpose of the grinding was to destroy the fibers and produce a dust to test the role of the chemical composition in producing disease. The results of the Gardner studies, and most subsequent studies, indicated that the pathogenic property of asbestos is due in large part to its fibrous composition and shape rather than its chemical composition (20).

Carcinogenic Properties of Asbestos

In 1935, Lynch and Smith (21) reported the first case of carcinoma of the lung in a patient with asbestosis. Throughout the late 1930s and early 1940s, other articles were published discussing the occurrence of lung cancer in asbestotics (22–24). In 1941, Nordmann and Sorge (25) published the results of their animal experiments that resulted in the production of pulmonary cancer in 20 percent of the animals who survived the inhalation of asbestos. By 1949, the association between asbestosis and lung cancer had been firmly established and was the subject of an editorial published in the *Journal of the American Medical Association* (26). Further evidence of the carcinogenic potential of asbestos was provided by Doll's (27) large-scale epidemiological study in 1955 wherein he estimated the risk of lung cancer in asbestos workers to be 10 times that in the average individual.

ORIGIN OF THE ASBESTOS GUIDELINE AND OTHER GUIDELINES: SURVEY AND ADOPT

Once asbestos was recognized as a hazardous agent, a guideline for excess asbestos exposure was explored in an attempt to protect the tens of thousands of workers in the United States who were being exposed. The first value for the asbestos guideline for dust control arose by analogy to silica (28). The silica guideline was based on engineering feasibility, not on the prevention of adverse health effects (29). The adequacy of the proposed asbestos guidelines was first challenged in 1935. Clark and Drinker (30), relying on unpublished Metropolitan Life studies, indicated that the safe exposure limit for asbestos was not known, but that Metropolitan Life "prefers to see the dust count below 5 million (ppcf) and welcomes still lower figures." Unaware of the unpublished Metropolitan Life data, in 1938 the U.S. Public Health Service proposed a tentative Maximum Allowable Concentration for asbestos of five million particles per cubic foot (5 mppcf) (31). One of the authors of this study recognized the inadequacy of the proposed guideline in a second 1938 publication (32) (see below). By 1938, there was no national standard-setting process to incorporate the proposed guideline, however inadequate, into an enforceable occupational standard.

In 1938, the National Conference of Governmental Industrial Hygienists (NCGIH), a precursor to ACGIH, was formed. Composed entirely of volunteer industrial hygienists who were self-appointed creators of safety guidelines, its goal was to promote industrial hygiene and sanitation (33, 34). In 1942, NCGIH began to develop a list of proposed guidelines for different substances, including asbestos (35). Without any review of research or data, the Subcommittee on Threshold Limits of NCGIH presented a table of "Maximum Permissible Concentrations" for various hazardous atmospheric contaminants (35). The principal source for the table was a survey of various state industrial health units. The value of 5 mppcf for asbestos had been accepted by at least seven states, while one state used a MAC of 15 mppcf. Some of these states used values from a list furnished by the U.S. Public Health Service, which stated that its own values were "not applicable in light of present knowledge." The Subcommittee recognized the inadequacy of all the data when they wrote, "The table is not to be construed as recommended safe concentrations" (35).

In 1946, despite this recognition of inadequacy, NCGIH, now renamed ACGIH, adopted most of the values in the table from the 1942 meeting, including the asbestos value of 5 mppcf (36). Dr. Frederick of the Subcommittee on Threshold Limits stated that "values have been compiled from the list reported by this sub-committee at the 5th annual meeting of NCGIH in 1942, from the list published by Warren Cook in Industrial Medicine, vol. 14, p. 936, 1945, and from published values of the Z-37 committee of the American Standards Association." In 1945, Warren Cook's (37) list was based on consultations with various industrial hygienists concerning the guidelines that were being used at the time. Cook provided minimal documentation for most of his proposed guidelines. More than 70 percent of the guidelines were based solely on acute toxicity studies rather than studies to determine chronic health effects. ACGIH never reviewed literature or conducted any other studies of the protection afforded by these numbers. No research was done between 1942 and 1946 that might have convinced the Committee to accept the 5 mppcf value for asbestos. The Threshold Limits Committee did not investigate or evaluate—it surveyed and adopted. This set the pattern for the next three decades of ACGIH-published guidelines.

DEFINING THE PROBLEM: PROBLEMS WITH DEFINITION

The fundamental problem with ACGIH's policy of "survey and adopt," aside from its implication for the reliability of the guidelines, is that it never defined the parameters of the asbestos guideline. Instead, ACGIH merely recorded that the guideline for asbestos was 5 mppcf of air. ACGIH's failure to define the guideline resulted in a myriad of questions concerning its applicability (and, therefore, the applicability of other guidelines): Did the guideline pertain to 5 million particles of dust containing a small amount of asbestos or 5 million asbestos fibers? Was the

proposed value an average or a maximum level that should not be exceeded? What level of protection did the guideline provide (short-term irritation, chronic disease, or cancer)? What was the safety factor? Each of these issues is discussed more fully below.

Total Dust Containing (Some) Asbestos versus 100 Percent Asbestos Fiber

Dreessen and coworkers' (31) 1938 U.S. Public Health Service (USPHS) study of two asbestos textile plants in North Carolina formed the basis of the 5 mppcf guideline. In that study, Dreessen suggested a tentative danger level of 5 mppcf to reduce the risk of asbestosis among asbestos workers until better data could be accumulated (31). Even a cursory review of the study reveals that Dreessen's tentative danger level was a measure of total dust (fibers and dust particles), where the average asbestos and cotton fiber content of the dust was only 9 percent (Table 1).

The fact that USPHS's tentative level was intended to be a measure of total dust that contained asbestos fiber is supported by the technology available at the time of the study. Except on an experimental basis, no technology was available to specifically measure fiber concentration in air until the late 1960s. The impinger, developed in the late 1930s, was the measurement device most commonly employed by the U.S. industrial hygiene community until the late 1960s, and was at times prescribed by ACGIH for the measurement of mineral dust exposures. An impinger sampling did not distinguish between fibers and particles of other shapes (38).

Table 1

Composition of dust in textile mills studied by Dreessen and coworkers (31) 1938

Activity	Percent asbestos and cotton
Weaving[a]	26
Weaving[b]	12
Picking[a]	8
Carding[a]	7
Twisting[a]	5
Twisting[b]	5
Crushing[a]	1
Average	9[c]

[a]Plant A.
[b]Plant B.
[c]Not in original.

Further support for the interpretation that the guideline was a total dust standard is furnished by the 1946 study of Fleischer, Drinker (a member of the first ACGIH TLV committee), and colleagues (39), which contained the only definition of the guideline published between 1946 and 1962. In their paper the asbestos guideline was defined as a total dust standard.

Finally, in 1968, ACGIH imposed a unique restriction on the use of the asbestos guideline which indicates that it believed the guideline to be applicable to total dust. In 1968, ACGIH reported that the guideline for mixtures containing asbestos should not be raised even when there is a reduction of the asbestos percentage in the dust due to an admixture with other nontoxic substances (40). Therefore, even if the percentage of asbestos in dust generated from a source decreased because of the mixture of nonlethal dusts, the guideline remained at 5 mppcf. By recognizing that any amount of asbestos in a dust justified the implementation of the 5 mppcf guideline, ACGIH recognized that the asbestos guideline was a total dust standard.

Maximum versus Average

The Subcommittee on Threshold Limits that created ACGIH's proposed 1946 guidelines termed them "Maximum Allowable Concentrations" (36). ACGIH, however, did not explicitly define this term until 1953 (41). The values could have been interpreted as a maximum average level, a maximum level, or both, but ACGIH did not identify which guideline belonged with which definition (36). In fact, different definitions applied to different guidelines.

Despite ACGIH's failure to specifically define the level of permissible exposure, a letter written by Philip Drinker (42) reporting on asbestos dust levels created aboard ships by insulators and other asbestos product users supported the interpretation that the asbestos guideline represented a maximum level not to be exceeded. Drinker, Head of Industrial Hygiene at Harvard University and consultant to the U.S. Navy and, as noted above, a member of the first TLV committee, wrote that "Dust counts in the room where the men were working were very much higher than anyone would recommend—they ran up to 25 million. A figure of 5 million for asbestos is recommended." Obviously a single exposure above 25 million for a short time (20 minutes to an hour) would still leave one well below the average, 5 mppcf for a whole day. Therefore it is clear that Drinker interpreted the asbestos guideline as a maximum level not to be exceeded.

In 1948, ACGIH changed the name of the guidelines from "Maximum Allowable Atmospheric Concentrations" to "Threshold Limit Values" (43). Not until 1953 did ACGIH provide, for the first time, a preface to explain how the numbers were to be used (41). The values were defined as both averages and maximum values not to be exceeded. The preface opens by describing the values as "maximum average atmospheric concentrations" and ends with "It is felt, at the present

time, that workers should not be exposed to a working environment containing any of these substances in excess of the value indicated."

The research community also interpreted the guideline as a maximum value not to be exceeded, in part because it was acknowledged that peak exposures for intermittent periods could be more harmful than low average exposures for long periods of time. In 1953, McLaughlin wrote (44):

> The concentration of dust which can be inhaled without danger varies according to the nature of the dust and also to the length of time that a man is breathing it. Again, the intermittent exposure to high concentrations of dust may be more dangerous than exposure to lower concentrations over a longer period.

In 1961, ACGIH arbitrarily redefined these guidelines for a second time. ACGIH explained that the values now represented "time-weighted average concentrations" which "may be exceeded for short periods" depending upon a number of factors such as the nature of the contaminant, whether very high concentrations even for short periods produce acute poisoning, whether the effects are cumulative, the frequency with which high concentrations occur, and the duration of such periods (45). Under most circumstances, averaging exposure levels in this manner results in an increase in total exposure to the toxic substance (Figure 1). ACGIH did not offer any justification for the resulting increase in permissible exposures to most substances.

Notwithstanding ACGIH's newly created application of the guidelines as "time-weighted average concentrations," the guideline for asbestos remained a maximum level not to be exceeded. At the 1967 meeting of ACGIH, British industrial hygienist S. A. Roach specified the manner by which dust counts should be conducted and interpreted to maintain compliance with the ACGIH guideline. He maintained that the ACGIH guideline should be interpreted such that excursions above any limit should not last more than 15 minutes (46). The "test TLV factor" specified how much a 15-minute excursion could safely exceed the TLV. Roach noted that ACGIH had not yet determined a "test TLV factor" for mineral dusts (46). Therefore, without a safe excursion level for mineral dust, the guideline for asbestos could only be interpreted as a maximum limit not to be exceeded.

When sampling for compliance with the ACGIH guidelines, industrial hygienists typically gathered four to eight samples of 10 to 15 minutes each during an 8-hour shift. Noncompliance with the guideline would result if any single sample was above the guideline value. Accordingly, the guideline was viewed as a "speed limit," a number that should not be exceeded and above which values could not, with impunity, be averaged with low values or hours off the job.

Throughout the entire process of shifting definitions and terms, the absolute value for the asbestos guideline remained at 5 mppcf. ACGIH did not review or

conduct any new studies on the adequacy of the guideline to determine whether, under the various definitions, 5 mppcf protected against asbestosis.

Level of Protection

In discussing the level of protection offered by the guidelines, Manfred Bowditch remarked at the 1943 NCGIH meeting (48):

> What you mean by toxic seems to me relatively unimportant to the discussion. We don't talk about toxic limits in our standard. We simply say that there are maximum allowable concentrations. We don't even say why they are maximum or why they are allowable.

Obviously, Bowditch did not have a clear understanding of the meaning of "maximum allowable concentrations." His accurate assessment of the confusion surrounding MACs was compounded by ACGIH's failure to define the guidelines and the level of protection accorded by compliance with those guidelines. By 1946, the Subcommittee on Threshold Limits had identified three possible levels of protection (36):

1. *Just Escape Health Effect*

   > One concept is that the M.A.C. value should represent as accurately as possible that concentration at which a worker exposed for a sufficient period of time will just escape physiological or organic injury and occupational disease.

2. *Provide a Margin of Safety*

   > A second concept is that the M.A.C. should represent some fraction of that concentration which will injure the worker in order to allow a margin of safety in the design of protective equipment and guard against possible synergistic effects in the case of multiple exposures.

3. *Provide a Margin of Safety and Protect Against Irritants*

   > A third concept is that the M.A.C. should perform the functions of the former concepts and in addition provide a work environment free of objectionable but non-injurious concentrations of smokes, dusts, irritants and odors.

Each of these possible interpretations requires a different analysis and computation and should result in a different guideline value. Unfortunately, in 1946, when ACGIH first published its list of guidelines, it merely adopted a wide variety of guidelines that applied to a multitude of substances, without any definition or discussion of what level of safety the numbers were intended to ensure (36). In

1947, the Committee finally selected a definition for the protection level of the guidelines, a definition that had not even been proposed earlier (49). The definition selected was proposed by L. T. Fairhall and defined as "that amount of gas, vapor, fume or dust which can be tolerated by man with no bodily discomfort nor impairment of bodily function, either immediate or after years of exposure."

Contrary to customary practice, ACGIH selected the numbers first, and then later defined the level of protection offered by these numbers. Furthermore, while the definition that ACGIH finally adopted indicated that adherence to the guidelines would protect against chronic exposure, most of the numbers were based on short-term human or animal studies. ACGIH did not conduct any investigation to guarantee that the guidelines complied with the level of protection as the Conference defined it. ACGIH merely picked a definition without any examination or study. In addition, after selecting a definition, ACGIH never clarified what was meant by "bodily discomfort" or "impairment of bodily function." In the case of the asbestos guideline, this is particularly significant, since, as we will detail below, ACGIH ignored the carcinogenic potential of asbestos until 1971 (50).

The effect of these unclear and changing definitions on any attempt to provide a safe working environment could only have been negative. ACGIH's publications provided numbers with no meaning. On the one hand, the scientific basis for the guidelines was questionable. On the other, given that there was no clear understanding of how they were to be used, application of the guidelines could vary with the whims of the industrial hygienist. In the end, as we discuss below, the asbestos guideline was generally ignored by shipbuilders, manufacturers, and mining companies. This situation might have been ameliorated quickly, if ACGIH had had an adequate review process. Unfortunately, this was never in evidence.

REVIEW PROCESS

In 1953 and 1961, ACGIH stated that the proposed values were to be "reviewed annually by the Committee on Threshold Limits for changes, revisions or additions" (41, 45). The first documentation of the guidelines, however, took 7 years to produce. According to Herbert Stokinger (51), chairman of the TLV Committee in the 1960s, the 300 or so TLVs "were farmed out in numbers and subject according to the 6 members' intimate knowledge and familiarity with the substance." This review process was time-consuming in part because the guidelines were based on sparse scientific criteria.

Although ACGIH claimed to conduct an annual review of the various proposed guidelines, between 1953 and 1961 no annual reevaluation of the guidelines occurred, since the first documentation of the guidelines was not complete until 1962. Furthermore, even after the documentation was produced, there is no evidence that ACGIH ever regularly conducted an annual evaluation of the existing guidelines. A review of the *Transactions of the Annual Meetings of the*

ACGIH indicates that there was rarely any mention of the evaluation of current values, there was no mention of current research being conducted on various substances, and there was no critical examination of research that had already been conducted (3, 35, 36, 40, 41, 43, 45, 46, 48–50, 52–71).

When the values were discussed at ACGIH meetings, as in the case of silica in 1962, the general inadequacy of the mineral dust guidelines was dramatically demonstrated in this discussion by Ashe (63):

> But let me bring out the specific case of an industry that is very close to Vermont, happens to be in New York, and happens to be out of business now. It went on for a long time. And the material that the industry was pulverizing was slate, making slate grinders. And that slate had thirty-five percent quartz content, the same quartz content as granite, and the existing feeling was [that a] threshold limit of twenty million dust particles per cubic foot of air was acceptable, and that industry accepted that, and they fought like hell to reduce it even to twenty. And we have a sanitorium that has many men who have died of silica tuberculosis because of an M.A.C. that was too high. . . . I have an x-ray file full of x-rays of men who are dead that will prove twenty million particles of granite per cubic foot of air is too much for them to live and work.

It should have come as no surprise to ACGIH that the silica standard proved ineffective. As we have already pointed out, the standard for silica exposure was initially based on engineering feasibility, not health considerations (29). ACGIH's failure to review the silica standard adequately was duplicated in the case of asbestos. Although the asbestos guideline was adopted in 1946, the first documentation concerning the guideline was not produced until 1961. In that documentation, ACGIH belatedly recognized that the guideline measured the wrong thing (45):

> While chemical analysis of collected samples of airborne dust correspond 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.

Thus, although the animal and human studies forming the basis of the asbestos guideline were based on particle samples, the disease was thought to result mainly from exposure to the asbestos fiber component of the dust. ACGIH's realization of this fact is not surprising since the asbestos guideline had been criticized on this basis in 1958 (72).

Despite the recognition that the asbestos fibers were the culprit in causing disease, ACGIH continued to recommend a guideline based on the measurement of total particulate matter, failed to alter the recommended value, and did not in any of its TLV booklets comment on the impact that such knowledge had on the adequacy of the particulate-based guideline.

An inspection of the *Transactions* of ACGIH indicates that the asbestos TLV was only reviewed in 1968 (40). At this time, it was recommended that the TLV for asbestos be adjusted downward to 2 mppcf or 10 fibers/ml (40). A typographic error, however, resulted in the recommendation being printed as 12 fibers/ml. This error, although acknowledged in the annual meeting of the ACGIH, was never corrected, and the TLV for asbestos was published as 12 fibers/ml for 3 years.

In addition to lowering the recommended level of exposure, ACGIH noted in the 1968 Documentation of the TLVs that the new asbestos guideline was only designed to protect workers "exposed for thirty years, a period rarely exceeded in America" (40). All other standards apparently continued to apply to a 40- or 50-year full working life of exposure to toxic substances. Workers exposed to asbestos were dying before they could complete the usual working life span, both because exposures were exceeding the guideline and because the guideline itself was insufficient to protect workers from cancer and asbestosis.

The ACGIH review process was virtually nonexistent. Although it stated it would annually review the proposed guidelines, in reality, ACGIH merely accepted and adopted numbers without any detailed evaluation of their scientific basis. After the numbers were adopted, ACGIH failed to conduct any studies or even to update values to reflect more current knowledge. In general, the longer a TLV had been on the books, the more outdated its basis was likely to be. The importance of such a critical review is evident in the consideration of two issues: the adequacy of the scientific foundation for the proposed asbestos guideline (Dreessen's USPHS study published in 1938) and the applicability of the guideline for insulation workers.

What a Critical Analysis of the Asbestos Guideline Would Have Revealed to ACGIH in 1946

As noted earlier, Dreessen's USPHS 1938 study examining asbestos-containing dust in a textile plant in North Carolina formed the scientific basis for the 5 mppcf asbestos guideline ultimately adopted by ACGIH. Had ACGIH critically reviewed this study prior to adopting the 5 mppcf guideline for asbestos, it would have determined that the guideline was inadequate. It is important to note that the inadequacies of the study were obvious and known to the authors (Sayers and Lanza) at the time (32). As noted by Sayers in 1938, a "fifth of those with an exposure of 50,000,000 to 99,000,000 particle years and one half of those with more than 100,000,000 particle years, had asbestosis." If a worker was exposed to Dreessen's proposed standard for 40 years of working life, he or she would have accumulated 200,000,000 particle years of exposure.

Similarly, in 1964 Lynn Schall (73), Chairman of ACGIH in 1963, emphasized major shortcomings in the scientific basis for the asbestos guideline. Although ACGIH was capable of making the same critical analysis before and/or after Schall's critique of Dreessen's study was published, it never commented on the

inadequacy of the basis of its asbestos guideline. Listed below are some of the essential limitations of Dreessen's proposed tentative guideline, which ACGIH would have discovered had it undertaken a critical review of Dreessen's work.

1. Because of a relatively young workforce, only 20 percent of the workers in his study were exposed to more than one-half the proposed guideline (200 million particle years total exposure over the course of a person's lifetime). In fact, asbestos-induced disease was noted in workers who had worked in the plants studied for up to 10 years, and who were exposed to dust levels between 2.5 and 5 mppcf. In addition, 50 percent of workers exposed to more than one-half the MAC (lifetime dose) had asbestosis. Furthermore, Dreessen referenced a similar study done in 1934 which found that 8 percent of workers exposed to average levels of 4.64 mppcf were found to have developed asbestosis (74).

2. Dreessen emphasized the fact that a very small percentage of the dust that he was measuring contained asbestos. As noted above, all dust counts but one recorded the percentage of (asbestos and cotton) fiber at less than 13 percent. The average percentage of fibers was 9 percent (Table 1). The techniques used by Dreessen did not allow differentiation between cotton and asbestos fibers. "No satisfactory technique could be developed for this purpose," according to Dreessen. Therefore, the asbestos fiber levels were even lower than the total percent fiber presented. Given this, even if one were to accept the adequacy of the 5 mppcf level of total dust, a proper interpretation of Dreessen's data showed that pure asbestos fiber exposures over 450,000 fibers per cubic foot caused disease (9 percent multiplied by 5 million total particles per cubic foot = 450,000 fibers per cubic foot).

3. Dreessen and others studying textile mill exposures looked at a relatively constant exposure level. The processes of milling, spinning, and carding asbestos went on continuously in a particular location within the mill and could be constantly ventilated. This is to be contrasted with much more variable asbestos dust exposures for product users, particularly insulators, but also for other workers using asbestos in relatively uncontrolled conditions. In these conditions, asbestos exposures as high as 1191 fibers/ml have been noted (scores higher than the equivalent previous total dust guideline) (75). Since Dreessen examined continuous exposures, the tentative value he recommended represented a maximum allowable concentration and an average.

4. Lynn Schall, commenting on the composition of workers in the USPHS study, made these points (73):

> 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 exposure (p. 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. . . . The book Silicosis and Asbestosis by Lanza 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!

In evaluating these limitations, ACGIH could have gleaned several key points from a critical review of Dreessen's study that should have been considered prior to the blind acceptance of the 5 mppcf guideline:

1. The tentative guideline applied to dust containing less than 13 percent asbestos and thus represented the concentration of total dust that contained a small percentage of asbestos fiber.
2. The 5 mppcf value was not a valid time-weighted average guideline because half of the workers exposed to more than half of the guideline (equivalent to 20 years of work at 5 mppcf average exposure) developed asbestosis.
3. Since Dreessen examined continuous exposures, the tentative value he recommended represented both a maximum allowable concentration and an average concentration.

ACGIH, however, did not critically examine Dreessen's paper. Instead, confusion and indifference abounded, and in 1962, 24 years after USPHS published its study, exchanges such as the following took place at the annual ACGIH meeting (63):

> Mr. Keppler: I have never been able to get clarification what is meant by that five million [mppcf], whether it is asbestos that is present? Is that the limit, or is that predicated on the percent of asbestos?
>
> Mr. Ashe: I think you brought up a question the committee needs to study. I think asbestos is one of the things that really needs to be investigated. There is no answer to your question. I know what you mean. I have been in asbestos plants where it was really dusty. You would swear it was a hundred [100 mppcf], and you take a sample and only get a count of five [mppcf]. As far as I could see the value of five was decided upon because that is the most anybody could ever come up with.

Thirty years after the USPHS study was published, ACGIH acknowledged criticism of the 5 mppcf guideline (40):

> A conference on the biologic effects of asbestos in 1965 called attention to the very real probability that the 5 mppcf limit recommended by Dreessen is inadequate to give complete working-life-time protection against all forms of asbestos. Medical data on which the limits had been based were inadequate; more than half of the asbestos workers studied were under 30 years of age and thus provided an insufficient exposure time for asbestosis to develop. Of the 105 workers exposed to <5 mppcf, 82 had worked <5 years; 101, <10 years; only 4 had >10 years exposure. Seven of 36 workers exposed to 5–9.9 years had asbestosis; 3 of 50 workers exposed to 10–19.9 mppcf for <5 years had asbestosis. Moreover, it was a "point-in-time" study; many of the ill were missing and the dead uncounted, hence not considered in the over-all evaluation of the limit.

The TLV for Insulation Workers

In addition to the qualifications on the asbestos guideline inherent to the Dreessen study, a review of the literature by ACGIH would have revealed other limitations to application of the asbestos guideline, especially in relation to insulation workers. In 1946, when ACGIH first adopted the values from the 1942 table of the Subcommittee on Threshold Limits of NCGIH, Fleischer and others (39) published a study of asbestos pipecovering operations aboard naval vessels. Because of the varied nature of the work and the inability to continuously monitor excess exposure, Fleischer and coworkers recognized that the TLV could not be relied on to protect insulation workers. They realized that shipyard exposures involved peak and average exposures that exceeded the guideline, and stated that, "in view of the varied character of the environmental dust exposure in the pipe covering industry on naval vessels, it is ***manifestly impossible*** to set a threshold" (39; emphasis added). As a result they made a series of recommendations designed to protect insulation workers from insulation-induced health effects (Table 2).

A study by Marr in 1964 also indicated that the TLV was not applicable to insulation work because the dust counts did not accurately reflect the levels to which workers were being exposed (76):

> Dust counts, taken with the Bausch and Lomb Dust Counter, appear in Table 1. The low counts on sampling do not appear to give an adequate indication of the actual hazard. During sawing of blocks and pipe sections and removal of old insulation, the work environment appears extremely dusty. Respiration filters often clog after an hour's work removing insulation.

Table 2

Recommendations from Fleischer and coworkers (39), 1946

1.	"During the handling, unwrapping, and unrolling of the asbestos, considerable dust arises, but appears to settle readily. A very fine water spray should be used for wetting down the material as a high velocity spray stirs up dust" (p. 10).
2.	"Inasmuch as this is a very dusty operation, the band saw should be enclosed in a room by itself and should be equipped with adequate local exhaust ventilation both above and below the saw table. Because of the mechanical difficulties in locating this exhaust properly, some of the dust will escape into the air and the operator should therefore wear an approved dust respirator" (p. 10).
3.	"Considerable dust is raised when the asbestos cement is dumped into the mixing trough and during the early stages of mixing. . . . The dustiness of this operation warrants the use of exhaust ventilation or respiratory protection or both, although neither is generally used" (p. 11).
4.	"Several shipyards reclaim their scrap pieces of prefabricated sections of insulation by grinding up this material and using it in the asbestos cement, all of which contributes considerable dustiness. Normally this job is done at infrequent intervals and only one or two men are exposed, but the operation should be isolated, general room exhaust supplied and an approved respirator worn by the operator" (p. 11).
5.	"Because of the varied nature of pipe covering operations in ship compartments, general exhaust ventilation is to be preferred. If the compartment is large, such as the main engine room, five air changes per hour are needed. In small compartments, such as living spaces, ten to fifteen air changes per hour are required" (p. 11).

Data from Balzer (77) in 1968 also demonstrated that insulation work routinely exceeded the asbestos guideline. He offered the following criticism of the TLV: "Anyone looking at the present basis for the threshold limit value (TLV) of 5 mppcf as recommended by the American Conference of Government Industrial Hygienists (ACGIH) in 1946 realizes that it is not based on solid evidence" (77).

One final limitation of the guideline applied to insulation workers is that it was never intended to apply to mixed hazard exposures (40). Most asbestos insulation products, and essentially all shipyard work and most other construction work, involved mixed hazard exposures. Almost all insulation products were mixtures of diatomaceous earth, calcium silicate, silica, and asbestos. Schepers and associates (78) showed that such exposure to a mixed hazard insulation product dust increases the risk of tuberculosis in animals. Silica produces fibrosis and increases the severity of tuberculous infection. Asbestos also causes fibrosis, but has not been shown to affect the severity of tuberculous infection. Therefore, since most

insulation products generate a mixed exposure, the guideline could not apply to the use of this material.

VIEW OF THE THRESHOLD LIMIT VALUE IN THE RESEARCH AND CORPORATE COMMUNITY

While we have examined the origin of the asbestos guideline and numerous problems with its applicability in the real world, we have not yet seen how it was viewed and used by industrial hygienists, researchers, and corporations. Most scientists who were conducting research for asbestos companies were aware of the inadequacies of the TLV. In 1943, Leroy Gardner (79), director of Saranac Laboratory, a major research center, wrote that the proposed asbestos guideline was not reliable.

In 1947, the Asbestos Textile Institute commissioned W. C. L. Hemeon (80), Head Engineer of the Industrial Hygiene Foundation of America, Inc., to conduct a study of the asbestos dust levels in their member textile factories. Hemeon found that the dust levels were not acceptable and questioned whether the 5 mppcf guideline accurately measured the potential hazard associated with the use of asbestos. Although the study was never published, the sponsoring companies were aware of Hemeon's observations that (80):

> The information available does not permit complete assurance that five million is thoroughly safe nor has information been developed permitting a better estimate of safe dustiness. It is nevertheless of greatest importance either that such assurances be sought or a new yardstick of accomplishment be found for accurately measuring any remaining hazard in the dust zone below five million for the elimination of future asbestosis depends upon the degree of control effected now.

Hemeon was not alone in his skepticism of the validity of the asbestos guideline. There was doubt as to the accuracy of the guideline in the first place, as evidenced by this excerpt from an article by Vandiver Brown, attorney for Johns-Manville (note that he questioned the validity of the asbestos guideline, but still envisioned the value as a maximum level not to be exceeded) (28):

> Maximum limits are prescribed for a great variety of materials with which I have no familiarity, but it is my earnest hope that these limits have been arrived at on the basis of a better factual and scientific background than exists in the case of asbestos. The allowable limit for industries using this material is a "mandatory" requirement of not more then five million particles per cubic foot, 10 microns or less in longest dimension. So far as I have ever been able to ascertain, no one can state with certainty what is the maximum allowable limit for asbestos dust.

Corporate Reliance on the TLV

Asbestos companies, through consultants such as Gardner, Lanza, Hemeon, and Vorwald, were aware that the guideline was a MAC and recognized its inadequacy. Still, corporate use of the guideline was limited. As discussed earlier, Fleischer's 1946 study provided evidence that dust levels in insulation work exceeded the guideline, and that the guideline proposed by USPHS in 1938 could not apply to insulation workers. From 1946 to 1961, no further studies were conducted to examine dust levels among asbestos product users. During this time frame, the only available data indicated that asbestos dust levels generated through their products' use exceeded the guideline (39).

From 1932 to 1964, 49 primary medical articles and 8 epidemiological studies were published documenting asbestos-related disease in insulation workers and others exposed to insulation products (2). Of these articles, 37, including all 8 epidemiological studies, were published between 1946 and 1964. Had the asbestos companies been concerned about and actually relied upon the ACGIH asbestos guideline as assurance that users of their asbestos products would not contract asbestosis, a review of the medical literature would have revealed three important facts: (*a*) Fleischer and coworkers had shown that the guideline did not apply to insulation workers; (*b*) use of insulation products generated dust levels that exceeded the guideline, based on nine studies published after 1964 indicating that dust levels exceeded the guideline (2); and (*c*) insulation workers were developing asbestosis from product use.

Furthermore, if the companies had relied on the guideline to protect workers, then the following steps would have been implemented:

1. Exposures during product use would have been measured. Although Fleischer showed that dust levels were not under sufficient control, companies did not follow up the Fleischer study in order to evaluate dust control methods and protect the health of workers.
2. Warning would have been given on the need to keep exposures below the guideline and risks of not doing so explained to product users. Included would have been warning about the possibility of disease from exposure below the guideline.
3. Workers would have been informed of the need to use a personal respirator if dust levels were found to exceed the guideline.

No asbestos product manufacturing company, however, ever published a study of the amount of dust generated during the normal use of its product in a work environment, and no asbestos manufacturer ever placed any warnings on the packages of its product explaining the asbestos guideline, the need to keep dust below that guideline, or the need to wear a respirator if the dust generated during the use of the produce exceeded 5 mppcf of air. The only impetus for evaluating

exposures during the installation and removal of asbestos products was the tremendous publicity surrounding Selikoff's 1964 study (81). By concealing data available to them, asbestos manufacturing corporations actively attempted to influence the value of the asbestos guideline, rather than informing ACGIH of its inadequacies for protection of workers.

CORPORATE INFLUENCE OF THE THRESHOLD LIMIT VALUE

Corporate influence of the TLV has occurred on many different levels. The most important aspect of this influence centers on the failure to transmit information, either by inadvertence or deliberate concealment, regarding both the inadequacy of the asbestos guideline and the full scope of the health effects associated with the inhalation of asbestos fibers.

Adequacy of the TLV

Studies performed in the 1930s by Metropolitan Life at the request of Johns-Manville Corporation indicated that the guideline needed to be "well below" 5 mppcf (30). Also, as discussed above, Hemeon's (80) study of asbestos textile plants for the Asbestos Textile Institute noted the limitations of Dreessen's study, expressed concern that the asbestos guideline was too high, and questioned whether, by measuring particles instead of fibers, the guideline offered the proper assessment of the risk associated with the use of asbestos. Despite the possible impact of an evaluation of these studies on the conventional wisdom concerning the validity of the asbestos guideline, neither the Metropolitan Life study nor the Hemeon report was ever published.

In response to these unpublished studies and the partial publication of Gardner's research by Vorwald and associates (19) in 1951, however, some asbestos companies adjusted downward their internal guideline for asbestos-containing dust. In 1954, Johns-Manville established a different threshold for asbestos (82). Recognizing that the pathogenesis of asbestos-induced disease emanated from the fibrous component of the asbestos, the company established an internal guideline of one million asbestos fibers per cubic foot. ACGIH was never informed that the asbestos companies utilized a modified asbestos guideline to control the dust in their plants. Johns-Manville may have been the only asbestos company to use a modified guideline.

Cancer and Corporate Influence on the Guideline

The corporations also influenced the recognition of asbestos as a carcinogen in the United States. Although ACGIH did not officially recognize asbestos as a carcinogen until 1974, by 1950 some parts of the medical community and all of

the asbestos mining and manufacturing corporations knew that asbestos probably caused lung cancer (2, 50). The following opening statement by a lawyer for Metropolitan Life Insurance Company in a recent law suit illustrates this point clearly (83):

> Since the 1930s it has been accepted that exposure to asbestos could cause a pulmonary disease called asbestosis. By 1950 scientists knew that asbestos could probably cause cancer of the lungs. . . . Before 1950 it was well known in this country, the proof will show, that asbestos was hazardous and, indeed, could kill you. The proof will show the United States Government knew it, the Navy knew it, the scientific community knew it, the medical community knew it.

One group whose knowledge is not mentioned in the above quote is the public or workers. This is because, while all of these other groups may have been aware of the dangers of asbestos, a huge effort was made to prevent the truth from reaching the public, especially the worker. There are many examples of this effort, made primarily by asbestos companies and their insurers (1, 2, 33).

After Gardner's death in 1946, Arthur Vorwald was named the director at Saranac. In 1951, working from a draft Gardner had prepared, Vorwald and others (19) published a report based on Gardner's dust studies in the 1940s. Prior to publication, significant portions of Gardner's draft were modified at the request of asbestos companies acting through Lanza (1). Lanza had all references to cancer or tumors in Gardner's draft deleted, even though Gardner found that 81.8 percent of mice exposed to asbestos fibers developed lung cancer. Gardner (79) found that this was in excess. Despite the claim by a footnote in the published paper that a "complete survey" of Gardner's work was reported, Vorwald did not include any of Gardner's research on the relationship between cancer and asbestosis. In addition, Vorwald omitted Gardner's comment that the guideline for a safe atmospheric concentration of asbestos dust, tentatively set at 4 or 5 mppcf, was "probably unreliable" (79).

Guidelines for noxious substances were one issue, but there was reason to think the thresholds were not protective if the substance was also a carcinogen. May Mayers (84) stated, "the maintenance in a factory workroom of Maximum Allowable Concentrations will not necessarily insure safe working conditions if a potential carcinogen happens to be present." In the same paper, Mayers identified asbestos as a probable carcinogen. Richard Doll (27) published an epidemiological study in 1955 that provided more support for the generally accepted belief that asbestos exposure caused cancer. Cook (85), in 1956, said that TLVs did not protect against carcinogenic substances and listed asbestos as one of three "known" carcinogens. The TLV for asbestos was not adjusted to protect against cancer, despite the fact that Herbert Stokinger, a member of the Committee on

Threshold Limits from 1953 to 1975 (chairman from 1962 to 1975), advised that TLVs for carcinogenic substances should be decreased (86):

> Several industrial substances are known or suspected cancerigens [*stet*]; many more are suspect on the basis of animal experiments. As a suggested method of approach, the following is offered: To the level judged safe for other types of systemic injury add a safety factor for carcinogenicity. The magnitude of the safety factor is suggested to be from 100 to 500.

Although Cook recognized in his introduction that asbestos was a carcinogen and commented on this issue before the Industrial Health Conference in 1955, no change was made to the asbestos guideline. This can be linked to the fact that Stokinger (87) was under the bizarre impression that asbestos acted as a carcinogen in England but not in the United States. In 1955, in explaining the asbestos guideline, he stated, "Mineral dusts are commonly of complex and inconstant composition, often varying according to locality, and thus are potentially capable of causing a variety of physiological responses. As a case in point, pulmonary carcinoma is commonly associated with the long-term inhalation of asbestos in England, but not in America" (87).

Stokinger relied on information from Anthony Lanza, assistant medical director for Metropolitan Life Insurance Co. (retired 1948) and consultant to Johns-Manville and other asbestos companies, to support the position that the effects of asbestos in Great Britain differed from its effects in North America (88–90). Lanza knew that there was no scientific basis for this argument. Nevertheless, he insisted that the British data on asbestos could not be applied to the U.S. experience. To promote his argument, Lanza unconvincingly tried to establish "differences between British and American findings." For example, he said in 1952 (90):

> I used to hear frequently in Canada that the Canadian asbestos is less damaging than the kind used in England where the major part of the asbestos used, I am informed by my English friends, is Rhodesian asbestos, a variety quite dissimilar in structure and physical characteristics to the Canadian kind.

Despite Lanza's attempts to justify his position, the previously published medical literature contradicted his assertions, and he had been rebuked by his contemporaries. Merewether responded at the 1952 Saranac Symposium to the above assertion made by Lanza (91):

> First of all, I think Dr. Lanza is misinformed about the proportions of asbestos used and where they are used in England. The original cases of Asbestosis, fifty years ago, were all Canadian asbestos. The earliest asbestos work in England was either seventy-five or eighty-two and there may have been some

crystalline fiber then, but very quickly the asbestos trade concentrated on the white Canadian crystalline.

Sparks (92) had written in 1931: "Of the asbestos imported in England, 80 per cent comes from Canada, so that it seems unlikely that you in the United States are dealing with a type of asbestos different from that employed in England."

Lanza was not ignorant of the conditions in the asbestos industry. He was aware of the criticisms of his position that asbestos caused cancer in England but not in the United States. Merewether (91), the leading authority on asbestos disease in England, had rejected Lanza's hypothesis.

Not only was the type of asbestos fiber used in the United States similar to that used in Britain, but it appeared to most researchers (with the exception of Lanza) that the dust levels in British plants were lower than exposures in American plants. According to Lanza (88): "This difference may be more apparent than real, but it is possible that the English factories may be more dusty than ours." According to Merewether and Price (93): "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." After all, regulations to control dust levels in British plants went into effect in 1931, whereas comparable regulations did not appear in the United States until 1972 (34).

Lanza was also not objective in his reporting on asbestos disease. He had previously altered published papers at the behest of asbestos manufacturers in order to help Johns-Manville influence worker's compensation laws. The asbestos mining and manufacturing corporations actively influenced Lanza to portray a relatively benign image for asbestosis (1). Vandiver Brown (94), senior corporate attorney for Johns-Manville Corporation, reviewed drafts of Lanza's 1935 paper on asbestosis. Brown suggested that Lanza's first conclusion contain a sentence that read: "Clinically, from this study it [asbestosis] appeared to be of a type milder than silicosis." Lanza had removed the sentence from his first draft, but Brown told Lanza that this conclusion would be "favorable to the industry and we should like to see [it] retained." In a letter sent 11 days later, Brown (95) summarized his recommendations to Lanza: "All we ask is that all of the favorable aspects of the survey be included and that none of the unfavorable be unintentionally pictured in darker tones than the circumstances justify. I feel confident we can depend upon you and Dr. McConnell to give us this 'break' and mine and Mr. Hobart's suggestions are presented in this spirit." Lanza (96) gave them a break.

With respect to the carcinogenic potential of asbestos, Lanza managed to create a controversy around a relationship that most scientists accepted. This artificial controversy and ACGIH's indifference to evidence concerning the carcinogenic potential of asbestos prevented downward revision of the asbestos guideline. Stokinger and the TLV committee members could have determined the facts

for themselves from published literature, but instead relied on the opinion of Lanza.

CORPORATE USE OF THE THRESHOLD LIMIT VALUE

We have seen that the asbestos guideline was rarely used by corporations to protect their workers or users of their product. Since 1978, however, the asbestos manufacturing companies have retrospectively relied on the TLV to protect themselves from liability in asbestos damage suits. This reliance is called the "state-of-the-art" defense. Asbestos companies argue that the existence of the ACGIH guideline relieved them of a responsibility to warn workers. The state-of-the-art is meant to be based on what people knew or should have known about asbestos health effects during the time frame (based on published and unpublished data). Henry Garrard (81), a defense attorney, outlined the use of this defense in a seminar for defense attorneys given in 1987. Excerpts from the seminar, entitled "State of the Art as a Defense—Is it Real?," demonstrate the approach of asbestos companies toward defending their claim that the ACGIH guideline exempted them from their responsibility to warn (81):

I. The Government Is the Springboard

> The argument is made continuously by plaintiffs' lawyers and doctors who frequently testify for the plaintiffs that the government was not involved in setting standards pertaining to asbestos in the work place. Jury studies have indicated that jurors still believe the government has a strong part to play in control of what goes on in the working environment and that the government has had great influence in that arena historically.
>
> Although OSHA is a creation of the 1970's, the basic mind set of the general public is that the government has been involved intricately in control of workplace exposures almost forever. Most of the people today have not grown up in work in an atmosphere that did not include significant government involvement. This can become a play for state-of-the-art throughout starting with Dreessen as an official of the Public Health Service. . . .
>
> After Dreessen, various publications, some of less importance, adopted similar positions. Interestingly, a study of various state laws also indicates that from time to time states, including New Jersey, adopted the 5 million particle standard as a relatively safe working standard. Depending upon the state in which a case is being litigated, this can be important to bolster the argument there was both a standard and government involvement. . . .
>
> Although the American Conference of Governmental Industrial Hygienists is not an official government organization, it was made up predominantly of government hygienists and the sound of the name gives it an official connotation.

Garrard also offers advice as to how to use published scientific articles to strengthen the defendant's case. The following insight refers to the conclusions reached by Fleischer's 1946 report on shipyard workers (81):

> Among the conclusions is the infamous "number 4" which states, "since each of the three cases of asbestosis had worked at asbestosis pipe covering and shipyards for more than 20 years, it may be concluded that such pipe covering is not a dangerous occupation."

In Fleischer's study, "such pipe covering" refers to pipe covering following specific procedures (Table 2), which are defined in their report (36, p. 11). Garrard appropriately uses the term "infamous" because he takes this quote out of context in order to misstate the authors' view that insulation work was hazardous unless performed using proper precautions. He continues (81):

> III. State-Of-The-Art Must be Kept Simple And Short From the Defense Perspective
>
> If the defense gets into an article contest upon cross-examination of plaintiffs' doctors or presentation of defense doctors, it is very difficult to win the state-of-the-art question. A better approach seems to be to take the dozen or so key articles which can be made out as major events and dwell upon those at least to show that the various manufacturers and suppliers of asbestos products were not historically without some scientific basis for continuing to market products. . . .
>
> Additionally, industrial hygienists who are not medical doctors probably should be used to a greater extent than they are used now to show the newness of that field and how they in fact rely upon the threshold limit value concept in general. After all, the threshold limit value concept is probably the best thing the defense has in its arsenal.

Unfortunately, the threshold limit value "concept" was far from the best protection for workers and others, thousands upon thousands of whom have died or been injured as a result of unnecessary exposure to asbestos. In fact, it appears that representatives within the industry originally saw it as a means to protect their interests, in an era of increasing personal injury litigation. Discussing a plan for dealing with the "dust problem," industry representatives in 1935 recommended that "Authoritative and approved standards for the control of industrial dusts" should be developed, "which, if complied with by industries, or by industrial companies, will act as a defense against personal injury suits" (97). Half a century later, the scheme appears to have been put into practice, although its flimsy appeal has been debunked by meticulous scrutiny.

CONCLUSION

We have reviewed the history of the asbestos TLV in order to gain insight into current problems with occupational health standards. This review demonstrates the following:

1. The asbestos TLV, like most ACGIH standards, was based on short-term animal and human studies rather than chronic studies (98).
2. The asbestos guideline was inadequately reviewed by people who cared little for gross insufficiencies in the scientific basis of their guideline.
3. The asbestos TLVs, like most current TLVs developed by ACGIH, could not be relied upon to protect workers or the public.
4. Corporate influence of guideline-setting and medical literature protected economic interests rather than worker or public health.

Companies never relied on the guideline to protect workers, and ACGIH failed to investigate a safe threshold for the use of this material. This combination of scientific indifference and corporate greed resulted in an occupational and environmental health disaster. This would be a matter of the past if there were not other potential disasters waiting to happen. OSHA, while a government agency and at least theoretically accountable to the public, publishes many guidelines taken directly from ACGIH, and both organizations are influential internationally. Any inadequacies in their standards will have magnified effects.

> Those who cannot remember the past are condemned to repeat it.
>
> George Santayana

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