Am. Ind. Hyg. Assoc. J. 47(9):515-523 (1986)
(1986 Cummings Award Lecture)

Asbestos and Disease: An Industrial Hygienist's Perspective

MORTON CORN, Ph.D., CSP
Professor and Director, Division of Environmental Health Engineering, School of Hygiene and Public Health, Johns Hopkins University, 615 North Wolfe Street, Baltimore, MD 21205

Introduction

I was not personally acquainted with Donald Cummings, but I know of him. At the Harvard School of Public Health in the mid-1950's he was occasionally referred to as part of the famous Saranac Laboratory team consisting of Leroy Gardner, Homer Sampson and Don Cummings. Cummings was the hygienist, a man exhibiting professional competence, curiosity and energy relative to investigation of the dust silicosis tuberculosis interaction. He was said to have had an abiding belief in our capacity to unravel this complex biological interaction, as well as other pneumocomotic diseases of our industrial society. His tragic and untimely death in an airplane crash in 1942 curtailed the life of a man who, by all accounts, had his major scientific and professional contributions ahead of him. It is a privilege and an honor to be selected to deliver this address honoring Donald Cummings.

The subject of this lecture is an industrial hygienist's perspective on asbestos, and United States approaches to reducing the risk of disease to those inhaling this extraordinary material. Asbestos has probably received more attention in the United States and worldwide than any other potentially toxic agent addressed by practitioners and investigators in the fields of industrial hygiene, occupational medicine.

Dr. Morton Corn, Ph.D., CIH, currently is Professor and Director of the Division of Environmental Health Engineering, School of Hygiene and Public Health at The Johns Hopkins University, where he has been a faculty member since 1980.

Prior to his appointment at Johns Hopkins, Dr. Corn advanced through the ranks from assistant to full professor while on the faculties of the Graduate School of Public Health and the Department of Chemical Engineering at the University of Pittsburgh (1962-1979). A leave of absence from 1975 to 1977 presented him the opportunity to serve under President Ford as Assistant Secretary of Labor for Occupational Safety and Health in the United States Department of Labor.

While obtaining his undergraduate degree in Chemical Engineering from Cooper School of Chemical Engineering Dr. Corn worked summers as a Research Assistant for the U.S. Atomic Energy Commission, thus beginning a career that has earned him numerous awards, fellowships and other honors.

Beginning with the New York State Regents Scholarship, which he was awarded from 1951-1955, Dr. Corn has amassed a lifetime of achievements,

including the National Science Foundation Postdoctoral, the John Simon Guggenheim Fellowship, the USAEC Fellowship, awards for published works, and invitations as guest speaker and lecturer at conferences throughout the world.

Dr. Corn also has served on various panels and committees, such as the Environmental Protection Agency Science Advisory Board (1977-1984) and the Office of Technology Assessment Committees on Control Technology in the Workplace and Hazardous Wastes.

In 1981 Dr. Corn was elected Vice Chairman of the American Conference of Governmental Industrial Hygienists, succeeding to Chairman in 1983. In 1984 he was elected President of the Association of Universities in Occupational Safety and Health. Dr. Corn currently chairs the Industrial Hygiene Commitee of the International Resource Center in Occupational Safety and Health; and is a member of NIOSH's Mine Health Research Advisory Committee.

Among his other memberships, Dr. Corn also belongs to the American Association of University Professors; the awards committee of the ACGIH; the American Industrial Hygiene Association, as a member of the Management Committee; the American Institute of Chemical Engineers, full grade; American Public Health Association; Air Pollution Control Association; British Occupational Hygiene Society; Society of Occupational and Environmental Health, founding member; and numerous others.

Dr. Corn's published works include papers, book chapters, and conference and symposia proceedings dealing with the subjects of aerosol physics, air pollution, industrial hygiene, safety in the workplace and public policy.

occupational epidemiology and toxicology. One could argue that more is known about the toxicity of asbestos and the dose-response curve for its inhalation by those exposed than is known about any other industrial material. Asbestos has created economic crises in selected corporations responsible primarily for its production and product distribution, causing two major U.S. corporations to enter into Chapter 11 bankruptcy.[1] The concern for asbestos has spread from those exposed occupationally to those experiencing nonoccupational exposure. Asbestos has precipitated regulation of the nonoccupational environment by the Environmental Protection Agency and the Consumer Product Safety Commission in the United States.

One could review our experience with the health effects of asbestos from the perspective of the lawyer: asbestos has set precedents in personal injury and property damage litigation. One could also view the asbestos experience as a case study in the evolving occupational and environmental medical literature, where scientific and technical precedents have been established. There are numerous facets to the asbestos story and one could select different vantage points to observe and evaluate those facets. I focus here on the industrial hygienist perspective. What can we learn, as individuals and as a profession from this experience, this extraordinary case of societal utilization of a valuable material and the associated growing recognition of its disease potential?

Background to the Occupational Standard

My introduction to asbestos occurred in 1955 as a graduate student in Industrial Hygiene at the Harvard School of Public Health. Our class studied the properties of dusts and fine particles in general, under the tutelage of Professors Leslie Silverman, Philip Drinker, and Charles Williams. In retrospect, I was instructed extremely well on the technical assessment of airborne concentrations of asbestos. At that time we evaluated asbestos dustiness according to the American Conference of Governmental Industrial Hygienist's Threshold Limit Value (TLV) guideline of five million particles per cubic foot of air determined by light microscopy. Students were instructed by Dr. Williams in the appropriate sample collection by midget impinger, slide preparation, and microscopic counting procedures. Perhaps the first lesson to be derived from this experience was that we were not urged to critically evaluate the documentation of the TLV. The Dreesen study[2] of textile workers was the basis for the TLV guideline. It was an extremely limited cross sectional epidemiological investigation, characterized as follows in the first edition of the *Documentation of Threshold Limit Values*, published by the ACGIH in 1962:

> "The present threshold limit relates to the prevention of asbestosis. It was recommended by Dreesen, *et al.*, 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 5 mppcf, whereas numerous well marked cases were found above 5 mppcf. Counts were from impinger-collected samples in ethyl alcohol and distilled water. Both fibrous and non-fibrous 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."[3]

The above was the total documentation for the guideline in 1962. In 1955 the brief discussion of asbestos disease found in the book *Industrial Dust* by Drinker and Hatch[4] was the major reading for graduate industrial hygiene students on the rationale for the guideline. The TLV was for pure chrysotile fiber. In practice, U.S. industrial hygienists utilized the TLV for all situations where airborne asbestos was encountered.

It was not until 1968 when the British Occupational Hygiene Society (BOHS) published their occupational hygiene standard for asbestos that a specific level of risk for basal rales and x-ray changes was offered for asbestosis.[5] I

TABLE I
U.S. Asbestos Standards[12]

				Million particles/ per cubic ft.	Fibers/ cc	STEL,* fibers/ cc
1938		Recommended	TLV	5	30`	
1946	ACGIH	Adopted		5	30`	
1970		Adopted		2	12`	
1971		Proposed		-	5	
1971	OSHA	Emergency	TWA	-	2	10
1975		Proposed		-	0.5	5
1976		Adopted		-	2	10
1976	NIOSH	Recommended		-	0 1	0.5
1983	OSHA	ETS			0 5	
1984	OSHA	Proposed		-	0 4 or 0.2	

*Short Term Exposure Limit
`Approximate fiber equivalent

10003305

TABLE II
Factors Included in EPA Exposure Assessment Algorithm[11]

Condition of material
Water damage
Exposed surface area
Accessibility
Activity and movement
Air plenum or direct air stream
Friability
Asbestos content

and others instructed in industrial hygiene in the 1950's and 1960's were aware of the limitations of measurement techniques for asbestos-in-air, but were not seriously concerned with the adequacy of the TLV and were not addressing the need for change. Had our instruction focused more heavily on understanding the basis for the numbers in the TLV's, the uncertainties would probably have caused us great discomfort and concern. The BOHS publication profoundly affected the manner in which I assessed asbestos-in-air in the field during the late 1960's. I obtained midget impinger samples by the traditional U.S. method, but also obtained simultaneously collected membrane filter samples, expressing results as both mppcf (U.S. method) and fibers cc of appropriate size (BOHS method). Of course, part of the growing concern of hygienists was the increasing realization of the carcinogenic properties of inhaled asbestos, a subject soberly addressed in the 1968 BOHS standard.

Why is familiarity with the basis for a guideline and its weaknesses essential to the hygienist? While the standard is a single number, the interpretation of air sampling results and the accompanying recommendations will inevitably be shaded by the hygienist's insight into the basis for the standard. Standards, as we often repeat, are not fine lines between acceptable and unacceptable conditions (or risks). However, how we place the results in perspective for concerned clients will be a reflection of our own awareness of the "softness" or "hardness" of documentation supporting the guideline or standard.

In the 1971 third edition of the Documentation of Threshold Limit Values by the ACGIH there is a more critical paragraph on the Dreesen study, as well as a lengthier description of results relevant to a standard. The Dreesen study is further treated as follows:[6]

> "A conference on the biological effects of asbestos in 1965 called attention to the very real probability that the 5 mppcf limit recommended by Dreesen is inadequate to give complete working-lifetime protection against all forms of asbestos. Medical data on which the limits had been based were inadequate; more than

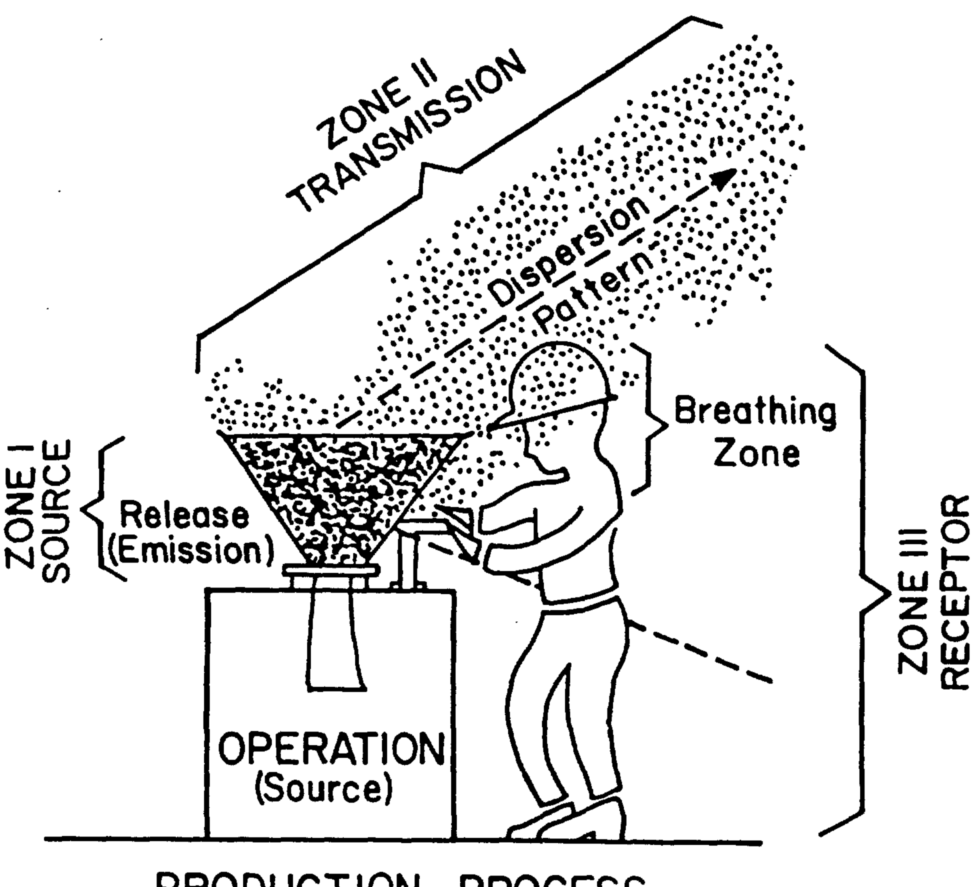

Figure 1 — Conceptual model of the three zones of influence to control workplace hazards.[20]

10003306

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 less than 5 mppcf, 82 had worked less than 5 years; 101 less than 10 years; only 4 had more than 10 years exposure. Seven of 36 workers exposed to 5-9.9 mppcf had asbestosis; 3 of 50 workers exposed to 10-19.9 mppcf for less than 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 recommended guideline based on the Dreesen study had stood for 33 years without critical reappraisal in the U.S. until the 1965 New York Conference[7] and the 1968 BOHS recommended standard prompted reappraisal. Let me be clear: I am not criticizing the TLV committee. The responsibility for reexamination of the standard was and is that of practicing industrial hygienists: it is too important a matter to leave entirely to the toxicologists.

Clearly, the first lesson of the asbestos story for industrial hygienists, particularly at a time when the field and this association is expanding to include industrial hygiene technicians, is that one must critically examine the supporting documentation for a standard when utilizing it in field situations. Fortunately, the Occupational Safety and Health Act, with its requirements for adherence to the Administrative Procedures Act for standards promulgation, necessitates agency publication of a Proposal for a standard, followed by comments and in every case to date, a public hearing. These procedures should force currently practicing industrial hygienists to familiarize themselves with the uncertainties of permanent OSHA standards. The limitation of this procedure for enforced learning is that OSHA has only passed 28 permanent health standards during its sixteen year history. The majority of standards in OSHA are still Permissible Exposure limits, as listed in Table Z-1 of the OSHA General Industry Standards.[8] They lack extensive documentation and associated engineering, medical, environmental, work practice and administrative controls. Thus, the burden remains on the hygienist to familiarize his herself with the epidemiological and toxicological literature on which standards or guidelines are based. The passage of a new standard by OSHA will, of course, involve public review of the health related data base.

How is the hygienist to integrate this type of knowledge into work and the discharge of his or her duties? The approach must be to indicate to a client and to those potentially affected in the work environment the airborne standard involved, but to moderate this with full clarification of the uncertainties associated with the numerical values of permissible exposure time weighted average or peak values. The degree of concern of the industrial hygienist must be related to the relative uncertainties of the standard. It is only in this way that the practice of industrial hygiene will be a science and an art, and not a mindless application of numbers and techniques. The Hazard Communication Standard of OSHA and state "right-to-know" laws should also serve to develop this approach.

Surrogate Measures of Exposure

In addition to the basis for the asbestos standard, we should briefly address the sampling methodology for airborne fiber concentrations. The early midget impinger mppcf methodology involved counting all particles present, although there was good indication at the time of adoption that this surrogate for the active agent may not apply in environments where all materials processed or used were not asbestos. The heritage of adoption of this weak surrogate measure for fibers was felt throughout the 1960's. For example, I was involved as consultant to the Pittsburgh Corning Corporation and designed dust control systems for their Port Allegany, Pennsylvania and Tyler, Texas Unibestos plants. These facilities later became the subjects of major personal injury litigation; unfortunately, large numbers of people contracted asbestos disease at these sites. In both the Tyler and Port Allegany cases I reviewed reports of practicing hygienists prior to undertaking my own surveys and dust control systems design. [A dust control system was installed in Port Allegany, Pennsylvania but not in the Tyler, Texas plant. These cases can now be discussed because the litigation has been completed.[9]] The hygienists had misinterpreted the 5 mppcf guideline* and had counted fibers, instead of particles and fibers, while determining adherence to the mppcf standard. Because it was a mixed material environment, the fiber counts were low when compared to the standard, as one would expect. Therefore, startling conditions of dustiness were encountered in Tyler, conditions addressed in previous hygienist reports and concluded to be in compliance with the 5 mppcf TLV for asbestos-in-air.

The lesson suggested is that adoption of a surrogate measure for extent of exposure to a toxic agent, although appropriate in an isolated or particular situation, may not be appropriate to many other situations. There must be an extraordinarily high level of care and foresight when a surrogate in assessment is adopted. Indeed, we must as a profession take every precaution to make sure our members understand the compromise inherent in the surrogate measure. Such a measure was adopted in the OSHA Coke Oven Standard. The benzene soluble organic portion of the respirable dust was invoked as the surrogate measure for the risk of exposure to coke oven fumes, a very complex mixture of potentially toxic materials. In this case, OSHA procedures, including public hearing and wide discussion of the strengths and weaknesses of the surrogate measure resulted in the compromise being widely understood. The current phase contrast microscopic method for examination of filter samples containing asbestos fibers does not measure asbestos fibers exclusively, a result of technical imitations of the microscope illumination. In mixed material environments a very prudent measure of exposure is obtained. Unfortunately, this is not well understood by many hygienists and the 2 f/cc OSHA standard is often thoughtlessly invoked in all environments. I will later return to the problems of a

*Because the plant was producing pipe insulation for the U.S. Navy, it was covered by the Walsh-Healey Public Contracts Act, the mppcf TLV was an enforceable Federal Standard under this Act

10003307

surrogate measure for asbestos in regard to nonoccupational exposure to asbestos. I will not further dwell on the safety factor or lack of safety factor the use of surrogate measures may include; my point is that those who use such surrogates must very clearly understand what they are doing.

Links to the Past

Under present regulatory procedures in this country, OSHA permanent health standards for airborne contaminants require that an initial determination be made of the concentration of the agent in air. If the concentration is above a triggering permissible exposure limit, periodic surveillance is undertaken. When the measurement technique and approach to asbestos evaluation in the environment was altered and the membrane filter method introduced in the late 1960's, efforts were not made to link this assessment methodology to past measurement techniques using the midget impinger and the mppcf method. Today we are struggling with so called "retrospective industrial hygiene."[10] In order to project the reduced impact of lowering standards for potentially toxic materials, it is necessary to have fairly reliable dose-response curves based on past exposures and health effects unfortunately already experienced. There must be a period of simultaneous environmental evaluation using new and old methodologies for assessment, with subsequent correlation of results. When we changed from the midget impinger mppcf technique to the membrane filter phase contrast microscopy technique, there should have been a required period of dual measurement to permit conversion of old measurements to the new framework. Such a required period could be part of the regulatory requirements or could be voluntarily undertaken by the industrial hygiene profession. We are now guessing at the conversion factors. I have personally simulated phased-out past production processes to perform simultaneous exposure measurements by these two measurements. *Surely the lesson of this experience, so vividly illustrated with asbestos where the projection of future disease is so important,[11] is that as a profession we must take steps to insure simultaneous measurement by new and old techniques when an assessment methodology is changed.*

Non-Occupational Exposure to Asbestos

Asbestos concerns spanned the years from the 1930's until the present time. They overlapped the creation of the Occupational Safety and Health Administration in 1970. One of the first issues addressed by OSHA was asbestos; in 1972 a permanent federal standard for asbestos was promulgated. Table I indicates the consistent lowering of the federal permissible exposure limits.[12] We are currently awaiting a further reduction in the federal standard. OSHA made it very clear to me and to other hygienists that the procedure up to that time of reporting our results to employers or clients exclusively, would not fulfill duties and responsibilities assigned to us by law. We are in an entirely different phase of discharging our responsibilities by sharing information. The implications of the Act for industrial hygienists was a subject that I addressed in 1976.[13] It remains a difficult subject area to sort out. Current hazard communication standards at the federal level and right to know standards at the state levels are articulating the types of concerns that we attempted to resolve as individuals or as groups of professionals during the 1970's and early 1980's. Needless to say, the awareness of these responsibilities suggested there was justifiable concern and that there should be scrutiny of other areas of asbestos exposure, areas not covered by the Occupational Safety and Health Administration because they do not occur in places of employment involving exposures to employees. This category of concerns has been called non-occupational exposure. The asbestos story provided evidence that exposed workers could carry asbestos from the workplace to the home, thus causing exposure of those not employed. Awareness of this potential for contamination and the use of asbestos in other environments has focused on asbestos in schools and buildings, an area addressed by the Environmental Protection Agency (EPA) under the Toxic Substances Control Act. It is an area engaged in complex property damage and third party personal injury litigation. The non-occupational asbestos exposure area also suggests certain lessons for the industrial hygienist; I'll now address several of these.

Air Sampling for Asbestos in Nonoccupational Environments

The EPA in a series of guidance documents often referred to as the Orange Book,[14] the Blue Book,[15] and the Purple Book[16] indicated early on that the agency had a very crystallized view of the role of air sampling in evaluating the risk of exposure of building occupants to airborne asbestos. In the 1979 orange document the following statement is made in Chapter 7 on Exposure Assessment:

> "Air sampling is inappropriate to estimate asbestos contamination and exposure. In the school environment, it is virtually impossible to establish exposure potential using standard air sampling techniques."[14]

Instead of relying on the well-established science and art of air sampling, EPA adopted an algorithm, a device that could be viewed as a tool for qualitative risk assessment. The EPA offered a series of relevant environmental factors, listed in Table II. Numerical weighting factors were then assigned to each environmental factor and a formula was used to derive a numerical score for the given situation. Based on the algorithm score, the responsibile party was directed to take immediate action (removal) or to postpone action. The environmental factors weighting was biased towards a resulting score which dictated immediate action, in most cases. What was not known by the professional community and the public in 1979 when EPA issued the first guidance document was that the algorithm had never been tested for its correlation with airborne asbestos concentrations in different environments. Subsequently, two contractors to EPA indicated the poor correlation of the algorithm scores with airborne fiber measurements.[17,18] The only highly consistent environmental factor was water damage to the material. Other investigations of algorithm validity

10003308

reached similar conclusions about the EPA algorithm usefulness.[19]

The need to correlate an algorithm with airborne fiber concentrations is essential if risk is to be estimated by a method other than measuring airborne concentrations. Figure 1 is a bedrock conceptual framework for exposure to environmental agents.[20] The mere presence of a source or agent is a potential hazard; the transmission of the agent to the receptor is necessary for a potential hazard to become a real hazard. Asbestos in a building is a *potential* hazard; asbestos-in-air concentration is the measure of that hazard being realized. The issuance of the 1979 guidance document by EPA in the absence of algorithm validation and in the presence of initial air sampling results discrediting the algorithm, can only be viewed as agency arrogance bordering on "chutzpah."[21]

In 1983 the "blue book" by EPA again discussed air sampling and the algorithm. It indicated that two of the eight factors assumed to correlate with measured levels of asbestos-in-air did, indeed, do so. These were water damage and the proximity of the material to an airstream created by a ventilation system. A report to the EPA by Battelle Memorial Institute was the basis for the conclusions.[22] In spite of these findings regarding the lack of validation of the algorithm in terms of fiber-in-air concentrations, EPA in the blue book recommended use of six of the factors to predict "fiber release potential." Once again, the agency recommended use of factors not validated by correlation with the property to be predicted, *i.e.*, fiber release potential, a term not well defined by the EPA to this day.

What about measuring airborne asbestos in nonoccupational environments? In the blue book of 1983,[17] EPA states the following in Section 3.2.3.:

> "Another proposed approach to assessing the need for corrective action is to measure asbestos fibers in the air. At best, this approach provides information only on current asbestos contamination and no information about the potential for fiber release and future air levels. Moreover, the use of air monitoring as an assessment tool involves substantial technical and economic problems which limit its use even for determining current levels of contamination."

After devoting two additional paragraphs to the limitations of air sampling, the following sentence concludes the air sampling discussion:

> "Given the limitations, EPA does not recommend the use of air monitoring for assessment purposes at this time."

In the latest "purple book,"[18] EPA states that it does not recommend air monitoring "as a primary assessment tool at this time." Algorithm factors are still endorsed, but with qualitative scores only. Air sampling *is* recommended for post abatement evaluation.

Why have I dwelled on this EPA asbestos story?

The lesson to the industrial hygiene profession is that we must always be alert and respond to obviously incorrect evaluations of some of the principal scientific tools of our profession. Our associations did not challenge the EPA in its denigration of air sampling. Much to my dismay, some hygienists have appeared in court on behalf of plaintiffs to reiterate EPA's downgrading of air sampling as a scientific tool. It eludes me as to how these individuals can, on the one hand, repeat the EPA position and then on the other hand, proceed in their daily utilization of air sampling methods for assessment of airborne hazards in a large variety of other environments. What is unique about asbestos in indoor environments?

Risk Assessment in Nonoccupational Environments

Another lesson stemming from shift of concern for asbestos in the workplace to asbestos in the nonoccupational setting is that this transition will occur with other potentially toxic agents. We must be prepared to place nonoccupational risks to potentially toxic agents in perspective with regard to other risks to life and health in the nonoccupational setting, utilizing the best techniques available. Risk assessment is certainly not an exact science, but in its present state of development it is a valuable input to the assessment of health hazards, as stated by the National Academy of Sciences.[23] Risk assessment highlights relevant factors related to the risk under scrutiny and it often permits scientific assumptions, or "inference guidelines"[23] to be made in order to estimate the risk quantitatively. If hygienists abandon these matters of risk assessment, others may lose sight of the health component of the dialogue. The current situation with regard to asbestos risk in non-occupational settings is a mess because EPA has never addressed the magnitude of the risks involved. Table III displays the ranges of airborne concentrations of asbestos in non-occupational settings in buildings and schools. The lifetime risks associated with non-occupational exposure to occupants of buildings and schools have been estimated by the National Academy of Sciences,[24] by a Royal Commission of the Province of Ontario, Canada,[25] and most recently by Hughes and Weill.[26] Table IV indicates lifetime deaths per million exposed attributable to six years of asbestos exposure in schools. The exposure concentrations assumed are reasonable based on Table III data. In my opinion, the model used for Table IV is a defensible one, but you must refer to the original article to follow its development. Hughes and Weill compared these risks to other commonplace risks in life. The upper estimate of approximately fifteen lifetime excess deaths (mixed fibers at 0.003 f/cc) would constitute an average annual rate of approximately 0.25 deaths per million exposed. The latter rate compares with approximately 1200 deaths for long-term smoking, 15 for bicycling, 15 for ingestion/inhalation of foreign objects and 10 from playing high school football. The upper estimate of an average annual rate of 0.25 deaths per million exposed would be equivalent to 0.75 annual U.S. deaths, based on EPA's estimate of 3 million students currently exposed.[26]

10003309

Postclearance Standard After Removal

The least defensible and perhaps strangest aspect of the current U.S. approach to non-occupational asbestos, is the standard for a clearance concentration for asbestos-in-air following a major abatement activity. Three states, *i.e.* Massachusetts, New Jersey and Rhode Island, have adopted standards of 0.01 f/cc after "aggressive sampling." Air samples are evaluated by the PCM, or NIOSH method. A brief review of Table III will reveal that *before* removal of asbestos in the building air concentrations were, on the average, at least an order of magnitude less than the clearance concentration in the majority of buildings. The justification for the standard is apparently that, because samples are collected after "agressive" sampling and because evaluation by the PCM method results in *all* fibers of a certain size being counted, the 0.01 f/cc standard actually represents an asbestos-in-air concentration far below 0.01 f/cc. This could or could not be a valid rationale: data have not been collected to accept or reject it.

Of course, the clearance standard could well be a license to permit building contamination to increase, resulting in more airborne asbestos fibers after removal than before. I am already aware of such cases, but data have not been systematically collected.

The clearance standard is a so-called concession to "practicality." Post removal air evaluation by electron microscopy has not been deemed feasible. PCM is rapid and would permit efficient conclusion of the removal contract and release of contractors. However, the risk to building occupants from inhalation of asbestos could well be greater after removal than before removal, when the original risk was presumably judged sufficiently compelling to trigger removal!

The illogic of this aspect of non-occupational exposure to asbestos is sobering if one considers the large expenditures of effort and money which may increase, rather than decrease occupant risk to asbestos disease. I question the conclusion that electron microscopy is not feasible for postclearance evaluation of air samples. Indeed, in my opinion it is the only way to certify an abatement effort as satisfactory. The standard should be that post clearance air concentrations are, on a statistically valid basis, lower than preabatement concentrations. If they are not, contractors should clean the premises until they are.

What can we conclude from the juxtaposition of the above estimates of risk from nonoccupational exposure to asbestos, the manner in which EPA has proceeded to regulate this risk and the current level of public concern for this potential hazard? Obviously, those responsible for national regulatory policy have lost sight not only of some well established principles of environmental assessment, but of comparative or relative risks and the setting of priorities. Today, members of the public need only learn of the presence of asbestos in a building and they want it removed. This attitude can be traced to the manner in which EPA presented the subject: it failed to relate the asbestos risk to other environmental risks. It is still not too late for our professional associations to issue a scientific document, albeit abbreviated, which states our position on these matters. Such a document would not be responsive to immediately pending specific regulation: therefore, the urgency with which this must be done is not great. We can utilize a democratic form of assessing membership input to reach a position on the value of industrial hygiene tools in assessing the risk and the value of risk assessment in comparative risk delineation *re*: asbestos in non-occupational environments.

TABLE III
Summary of Asbestos Exposure Samples in Different Environments[21]*

Sample Set	No. of Samples	Measured Concentration ng/m³ Median	Measured Concentration ng/m³ 90th Percentile	Equivalent Concentration (fibers/cc)** Median	Equivalent Concentration (fibers/cc)** 90th Percentile
Air of 48 U S cities	187	1.6	6.8	0 00005	0.00023
Air in U.S Schoolrooms without asbestos	31	16.3	72.7	0 00054	0 00242
Air in Paris Buildings with asbestos surfaces	135	1.8	32.2	0 00006	0.00107
Air in U.S. Buildings with cementitous asbestos	28	7.9	19.1	0.00026	0 00064
Air in U.S. buildings with friable asbestos	54	19.2	96.2	0.00064	0 00321

*Table III does not include all references and associated results, as contained in the more extensive NAS table[21]

**Based on conversion factor of 30 μg/m³ = 1 fiber/cc.

10003310

TABLE IV
Estimated Number of Lifetime Deaths Attributable to 6 Yr of Asbestos Exposure in Schools (Per 10^6 Exposed) By Fiber Type and Average Concentration[26]*

	Lung Cancer*	Mesothelioma†	Total
0.001 f/cc			
Mixed fibers	0.6	4.4	5.0
	(0.3 to 1.2)	(2.2 to 8.8)	(2.5 to 10.0)
Chrysotile only	0.6	0.9	1.5
	(0.3 to 1.2)	(0.4 to 1.8)	(0.7 to 3.0)
0.003 f/cc			
Mixed fibers	1.9	13.2	15.1
	(0.9 to 3.7)	(6.6 to 26.4)	(7.5 to 30.1)
Chrysotile only	1.9	2.6	4.5
	(0.9 to 3.7)	(1.3 to 5.3)	(2.2 to 9.0)

*Refer to original article for model assumptions *re*: calculation of table entries.

The tripartite descriptor of industrial hygiene has been recognition, evaluation and control. The movement of asbestos concerns from the workplace into the non-occupational environment suggests that we should add "anticipation" to these valuable descriptors of our activities. Anticipation, recognition, evaluation and control should be the future guiding lights of the field.

Recently, EPA issued a proposal to sequentially ban asbestos usage in the United States.[27] Asbestos is a unique and valuable material. Can it be used in certain unique applications at an acceptable level of risk? That is an issue on which we as a profession should sort out our views and make them known. Safety is a relative term; it is acceptable risk.[28] The tools of engineering controls, combined with work practices and personal protective equipment usage can reduce the risk of using potentially toxic materials to a level comparable to other commonplace risks in life. Should we ban a material from usage if it is not a trivial material with numerous substitutes? Asbestos is not in the latter category. The setting of a sequential asbestos ban leading to a total ban will establish a precedent that we, as industrial hygienists, should address publicly as a profession after crystallizing our viewpoint.

Summary

I have traced a personal thirty year journey of involvement with asbestos in the workplace and the nonoccupational environment, one still in progress, in an attempt to extract selected lessons for the industrial hygienist. Lessons for other professions, namely medicine, law and management have been studiously avoided in the interests of the scope of this presentation and permissible time. There are certainly numerous other lessons to contemplate. The movement of asbestos from the occupational to the nonoccupational environment is a case study that will undoubtedly be followed in the future by other potentially toxic materials. We must determine our position as a profession with regard to the tools we utilize, the procedures we follow, and our understanding of our moral and legal obligations to prepare for the often scientifically and technically unsupportable positions assumed by others, including governmental agencies, in their zeal to bring about change. We must discourage the opportunistic distortion of professional practices in these matters, and must issue well considered statements as a profession, statements relevant to the way these matters are addressed by society. We have a responsibility to lend perspective to these issues, to not permit understandably emotional responses to documented past severe health effects in other areas, such as the case of asbestos in the workplace, to carry over into conditions of very low exposures in the public domain. We must remind people of the relevance of dose-response and toxicological principles to assessment of risk. These principles are very much in the professional tradition of Donald Cummings. Perhaps that is what this address is really about, namely a reiteration of principles and an appeal, that as a profession we reassert these principles in order to discourage and thwart their distortion in the marketplace.

References

1. **Brodeur, P.:** *Outrageous Misconduct.* New York: Pantheon Books, 1985.
2. **Dreesen, W.C., J.W. DallaValle, T.I. Edwards, J.W. Miller and R.R. Sayers:** A Study of Asbestos in the Asbestos Textile Industry. *Pub. Hlth. Bull.* No. 241. Washington, D.C.: U.S. Pub. Hlth. Service, 1938.
3. **American Conference of Governmental Industrial Hygienists:** *Documentation of Threshold Limit Values.* Cincinnati, Ohio: ACGIH, 1962. pp. 11-12.
4. **Drinker, P. and T. Hatch:** *Industrial Dust*, 3rd Ed. New York: McGraw-Hill Book Co., 1959. pp. 45-46.
5. Hygiene Standards for Chrysotile Asbestos Dust. Comm on Hygiene Standards, British Occupational Hygiene Society. *Ann. Occup. Hyg.* *11*:47-69 (1968).
6. **American Conference of Governmental Industrial Hygienists:** *Documentation of Threshold Limit Values.* 3rd Ed. Cincinnati, Ohio: ACGIH, 1971. pp. 17-19.
7. **Whipple, H.E. (Ed.):** Biological Effects of Asbestos. *Ann. N.Y Acad. Sci.* *132*:1-766 (1965).
8. General Industry. OSHA Safety and Health Standards. 29CFR1910.1000, Table 2-1. OSHA U.S. DOL, Washington, D.C.
9. **Corn, M.:** Depositions in H. Yandle, *et al.* v. PPG Industries Inc., *et al.* Civ. No. TY-74-3-CA, U.S. District Court for Eastern District of Texas, Tyler Div., taken in Washington, D.C., Sept. 21, 1976; and A. Barber *et al.* v. United States of America C.V. No 80-321, U.S. District Court for Western District of Pennsylvania, taken in Baltimore, MD, Dec. 1-2, 1983
10. **Esmen, N.A.:** Retrospective Industrial Hygiene Surveys. *Am. Ind. Hyg. Assoc. J.* *40*:58-65 (1979).
11. **Walker, A.M., J.E. Loughlin, E.R. Friedlander, K.J. Rothman and N.A. Dreyer:** Projections of Asbestos-Related Disease 1980-2009. *J. Occ. Med.* *25*:409-425 (1983).
12. **Corn, J.K. and M. Corn:** The History and Accomplishments of the Occupational Safety and Health Administration in Reducing Cancer Risks. Ch 9 in *Reducing the Carcinogenic Risks in Industry*, edited by P.F. Deisler. New York: Marcel Dekker, 1984. pp. 175-195.
13. **Corn, M.:** Influence of Legal Standards on the Practice of Industrial Hygiene. *Am. Ind. Hyg. Assoc. J.* *37*:353-356 (1976)
14. *Asbestos-Containing Materials in School Buildings: A Guidance Document.* Part 1. U.S. Environmental Protection

10003311

Agency. Office of Toxic Substances. Washington. D.C March, 1979.

15 *Guidance for Controlling Friable Asbestos-Containing Materials in Buildings.* U.S. Environmental Protection Agency. Office of Pesticides and Toxic Substances, Washington. D.C. EPA Report No. 560/5-83-002. March, 1983.

16 *Guidance for Controlling Friable Asbestos-Containing Materials in Buildings.* U.S. Environmental Protection Agency. Office of Pesticides and Toxic Substances, Washington. D.C. EPA Report No. 560/5-85-002. June, 1985.

17 **Patton, J.L., C.W. Melton, E.W. Schmidt, J.S. Ogden, C. Bridges, T.A. Bishop, B.P. Price and C.W. Townley:** Draft Final Report on Asbestos in Schools. Columbus, Ohio: Battelle Columbus Laboratories, March 1980.

18. **Logue, E.E. and T.D. Hartwell:** Draft Report on Characteristics of the Asbestos Exposure Algorithm: Empirical Distribution, Correlations and Measurement Validity. Research Triangle, N.C.: Research Triangle Institute, Jan. 1981.

19 **Findley, M.E., V.E. Rose, G.E. Cutter and R.A. Windsor:** Assessment of the EPA Asbestos Hazard Algorithm. *Am. J. Pub. Hlth. 73*:1179-1181 (1983).

20 **Corn, M.:** The Role of Control Technologies in Preventing Occupational Disease. *Arch. Env. Health 39*:235-240 (1984).

21. Defined as "Presumption-plus-arrogance such as no other word, and no other language, can do justice to." From *The Joys of Yiddish*, by L. Rosten. New York. McGraw Hill Book Co., 1968. p 92.

22. **Constant, P.C., Jr., F.J. Bergman, G.R. Atkinson, D.R. Rose, D.L. Watts, E.E. Logue, T.D. Hartwell, B.P. Price and J.S. Ogen:** Airborne Asbestos Levels in Schools Draft Report, 1982 Washington, D.C., Office of Pesticides and Toxic Substances U.S. Environmental Protection Agency. Contracts 68-01-5915 and 68-01-5848

23. **National Academy of Sciences:** *Risk Assessment in the Federal Government: Managing the Process.* Washington, D.C.: NAS, 1983.

24. **National Research Council, Committee on Nonoccupational Health Risks:** *Asbestiform Fibers — Nonoccupational Health Risks.* Washington, D.C.: National Academy Press, 1984. p. 220.

25. **Royal Commission on Matters of Health and Safety, Canada:** Report on matters of health and safety arising from the use of asbestos in Ontario. Toronto, Ontario, Canada: Ontario Ministry of Government Services, 1984

26. **Hughes, J.M. and Weill, H.:** Asbestos Exposure-Quantitative Assessment of Risk. *Am. Rev. Resp. Dis.* 133:5-13 (1986).

27. Asbestos; Proposed Mining and Import Restrictions and Proposed Manufacturing, Importation and Processing Prohibitions. Environmental Protection Agency. 40CFR Part 763 FR Vol. 51, No. 19, 3738-3759. Jan. 29. 1986

28. **Lowrance, W.W.:** *Of Acceptable Risk.* Los Altos, Calif.: W Kaufmann, Inc., 1976. pp. 75-101

10003312