ILLINOIS POLLUTION CONTROL BOARD
January 6, 1971

In the Matter of:	)	
	)	#R71-16
ASBESTOS REGULATIONS	)	

OPINION OF THE BOARD ON ADOPTION OF REGULATIONS (BY MR. LAWTON):

Proposed regulations relating to asbestos and spray insulation were published in Newsletter #24 dated June 14, 1971. Hearings on these regulations were held in Granite City on October 6, in Chicago on October 15, and in Waukegan on October 19, 1971. Notice of the proposed final draft, together with the form of regulation proposed for adoption, were published on December 5, 1971 in Newsletter #37. Written comments were invited and a small number have been received. We adopt the regulations today in the form as published in Newsletter #37, modified by some minor clarifying language. Our principal concern in these regulations is to prevent or limit the emissions into the atmosphere resulting from the use of asbestos and asbestos-bearing products and the resulting disastrous pathological consequences resulting from ingestion and inhalation of this mineral. This Opinion will consider the source and types of asbestos, the uses of asbestos and asbestos bearing products, the cause of asbestos emissions and their demonstrated impact upon the health of the community, the measurement and monitoring of asbestos fibers and the means available for emission abatement and control. The modifications made in the substative provisions of the regulations, between their original proposal and ultimate adoption, will likewise be discussed.

The term "asbestos" is a name given to a variety of natural occurring mined silicates of a virtually indestructible character. The major asbestos minerals are chrysotile, crocidolite, amosite and anthophyllite. Of lesser importance are tremolite and actinolite. These minerals differ in their metallic elemental content, range of fiber diameter, flexibility and harshness, tensile strength, surface properties and other attributes that determine their industrial uses and which, in turn, affect their respirability, retention and biologic reactivity. Over 90% of what is mined and commercially used as asbestos is chrysotile, sometimes referred to as "serpentine" asbestos. The remaining minerals are collectively referred to as amphiboles. The United States uses about one-fourth of the world production of this substance, most of which is imported from Canada and Africa. (Ex. 3, Air Pollution Aspects of Asbestos, U. S. Department of HEW,September,1969, Litton Report. Ex. 19, Airborne Asbestos, National Academy of Sciences, 1971.) Asbestos deposits of commercial value in the United States are located principally in Vermont, California, Arizona and North Carolina. No commercially viable sources of asbestos are found in Illinois, a fact which might otherwise invoke a far more comprehensive set of regulations. The uniqueness and industrial usefulness of the mineral is a consequence of its flexibility, tensile strength, non-inflammability and its resistance to acids, alkalies and electricity.

Some asbestos fibers get into the atmosphere from non-industrial sources. See Asbestos Air Pollution Control, Institute for Environmental Quality, prepared by Colin F. Harwood, Ex. 20. These range from rock outcrops, farming and excavation for construction purposes to the use of talcum powder. Emissions from rock outcrops occur as a consequence of natural eroding processes such as earthquakes, temperature, wind and rain. Farming of soils in areas containing asbestos rock will likewise cause emission of these fibers. Construction requiring excavation in asbestos containing rock for housing, pipe-laying and road construction constitute a source of asbestos emission into the atmosphere. Recent research indicates that talcum powder, while basically a mineral rock dust, does contain fibrous material, and represents a threat of asbestos bodies.

Obviously, the thrust of the regulations does not seek to control asbestos emissions from these sources. Further, the absence of asbestos mining in Illinois eliminates this activity as a source of danger. It is the processing of asbestos in manufacturing and the use and fabrication of asbestos and asbestos and fiber containing products to which the regulations are principally directed. The health dangers inherent in asbestos inhalation arise at the start of the asbestos processing cycle and include the loading and storage of milled asbestos, the transporting of bagged asbestos to the opening area, fluffing of compacted fibers and the mixing of asbestos fibers with other materials. (Ex. 20, Harwood, Page 7.)

Principal user of all grades and varieties of asbestos fibers is the asbestos-cement industry producing asbestos-cement pipe used to convey water, sewage, industrial and gaseous products and serving as conduits for electrical and telephone cables. Other asbestos-cement industry products include roofing shingles, building boards, marine board and laboratory bench tops. To manufacture these products willowed fibers are dry-mixed with fine-ground silica, and a slurry formed by addition of water. The end products of these industries require finishing steps which again generate asbestos emissions. These include sawing, turning, drilling and sanding, each producing large quantities of asbestos-laden dust, and some clinging to the surface of the items being worked upon, again becoming a potential emission source.

A second major use of asbestos fibers is in the manufacture of asbestos vinyl floor tile and asbestos asphalt road paving compounds. Here again, emissions result from the manufacture of these products and to a lesser degree from the use and ultimate processing and fabrication. Asbestos papers represent a great variety of products used for roofing, insulation, linings, heat and chemical resistant insulation for pipes and automotive exhaust insulation. Pre-processing of asbestos fibers and the mixing of asbestos paper ingredients constitute an emission source. Again, the ultimate cutting and processing represents a further source of asbestos emissions into the atmosphere.

Asbestos paint and coating fillers utilize asbestos "shorts" recovered from the milling process where their relative indestructibility increases the density or opaqueness of paint. Where asbestos bearing paint is used in the spraying operation, the potential for emissions is substantial. Likewise, the wearing and aging of the paint becomes an additional source of emissions.

Asbestos friction materials and gaskets represent a wide use of these minerals. Emissions result from the fabrication, molding and trimming of these products. Asbestos is also used in the production of textile products. The term "roving" refers to the finished textile product, from which yarns are produced. Blended fibers are carded in machines where the operation is essentially open, presenting a serious emission source due to the combing action of the machine. Both the production of this product and its ultimate use present substantial sources of emission.

The spraying of asbestos for insulation constitutes one of the widest uses of the product and, undoubtedly, one with the greatest danger potential, not only to the health of the workers involved but to the public at large. Prepared asbestos cement slurry is pumped to the nozzle of a gun and sprayed directly to the surface, or alternatively a dry mixture of asbestos cement is pumped to the gun and mixed with water during the spraying operation. The material comprising the asbestos insulation is formed by combining asbestos, cement, and rock wool in proportions of 30%, 15% and 55%, respectively. The mineral most commonly used is amosite, possessing superior thermal properties. If color is required, crocidolite or chrystotile fibers are used. Among the unique properties associated with asbestos cement insulation are low thermal conductivity and inflammability and high strength, together with good acoustic features, low cost, easy thickness control and application. Initial cause of emissions from this product results from dry mixing of the asbestos cement and mineral wool components. Care must also be exercised during the storage and transportation of the bag mixture to prevent further emissions. At the construction site, the bags are open and the dry material emptied into hoppers where further emissions occur. The most significant source of emissions, of course, is in the spraying operation itself. High dust concentrations can be seen and measured at construction sites utilizing asbestos spraying methods. Our regulations impose an outright ban on this activity and impose stringent housekeeping requirements on all spraying of non-asbestos fibrous materials.

Additional emission of asbestos results from the use of pre-formed asbestos sections or blocks for insulation of pipes and boilers, and in the use of materials applied in a wet or slurry state. Asbestos cement products including roofing shingles, building boards and drain pipes have sealed surfaces and do not dust easily. However, emissions may result from their cutting or breaking. Other asbestos products used in construction and industry are asbestos paper, blankets, rope and sealing compounds. Emissions resulting from the use of these products depend on the type of material being fabricated, the amount and character of fabrication required, the location and nature of the site and the quantity of material being processed. *Tightly bonded composites will have less potential for* emissions than those loosely bound. See R.116 and following testimony of Pundsack; Thompson, Ex. 5, Asbestos as an Urban Air Contaminant; Ex. 4, Selikoff, Asbestos, "Environment", March, 1969. Twenty-seven industrial concerns in Illinois manufacture products using asbestos. Exhibit 20, Harwood, p. 56. Asbestos products are used in virtually all building construction and utility installation.

A particularly obnoxious source of asbestos emission with extreme difficulty of control is the demolition of existing structures. Asbestos insulation and products present in demolished structures generate substantial emissions into the atmosphere where control is difficult and the impact on persons in the vicinity, both workers and residents, is extreme.

For years, asbestos has been incorporated in building materials. In some forms of insulation and wallboard, the amount present is less than 20% of the total, but other materials consist principally or entirely of asbestos. When a building is demolished, areas of loosened asbestos are open to the ambient air and fibers are emitted. In general, single-family residential structures contain relatively small amounts of asbestos insulation. Demolition of industrial and commercial buildings that have been fireproofed with asbestos-containing materials will prove to be an emission source in the future, requiring control measures.

Asbestos is emitted into the atmosphere from brake linings and clutches. While these are unquestionably substantial sources of asbestos emissions in the ambient air, the character and potential of these sources have not been sufficiently documented to a point where we feel they can properly be the subject of regulatory action and control at the present time. Harwood, Ex. 20, p. 22 through 28. See Ex. 8 "Brake Lining Decomposition Products", Lynch, Journal of the Air Pollution Control Association, December 19, 1968.

Having described the principal sources of asbestos emissions we next consider their pathological implications. The Litton Report states, Ex. 3, p. 40:

"Asbestos is an air pollutant which carries with it the potential for national or worldwide epidemic of lung cancer or mesothelioma of the pleura or peritoneum. Asbestos bodies have been observed in random autopsies of one-fourth to one-half of the population of Pittsburgh, Miami and San Francisco and will probably be found in the people of every large city. ...the effects of the asbestos being inhaled today may not be reflected in the general health of the population until the 1990's or the next century."

The objective of the regulations must be two-fold, first, to protect those who by occupational activity or physical contiguity, either to the asbestos use or the asbestos user become the potential victims of this pollutant, in other words, to protect those with both occupational and environmental orientation; and secondly, to provide measures that will protect the ambient air against an asbestos build-up that will have adverse effect upon the general public beyond those occupationally or environmentally orientated at the source. As stated by Thompson, (Ex. 5),

"Because asbestos is virtually indestructible and so many of the asbestos containing products are used in towns, the average urban dweller is theoretically exposed to the inhalation of asbestos fibers on a residential basis."

After reviewing the incidence of death among asbestos workers, exposed to asbestos dust, over a 20-year period, Selikoff, Ex. 4, states:

"These experiences highlight one portion of the current spectrum of asbestos disease. It is now recognized that direct occupational exposure to asbestos results in a hazard much more significant than formerly appreciated. In the last several years, however, additional problems have been recognized which add another dimension: the possibility that the utilization of asbestos is associated with a much wider risk, perhaps one of the community at large. This is less well defined, much less well documented, but because of its potential importance, of considerable concern.

It is in this context that our regulations must be structured.

The onset of morbidity and lethal diseases have been attributed to asbestos inhalation and ingestion. Asbestosis, pleural calcification, lung cancer, and mesotheliomas are known to result from exposure to asbestos. Surveys of people living or working near asbestos mines and factories have revealed that many nonoccupational cases of asbestosis and mesothelioma have occurred either from asbestos in the polluted air or from asbestos carried home on the clothing of workers.

The fate of the asbestos fiber once it is inhaled and deposited in the lung is still questionable. The short fibers, less than .5 microns in length, have in the past been ignored, probably because they are much too narrow to be visible under a light microscope. The longer fibers are encrusted in an iron-bearing protein form termed "asbestos bodies," which are more easily visible.

Among asbestos workers, evidence of pulmonary asbestosis, also known as asbestotic pneumoconiosis, an asbestos induced scarring of the lungs, is common. This condition results in a diffuse fibrosis, usually in the lower lobes of the lung. Pulmonary asbestosis has been called a monosymptomatic disease, characterized by painful breathing and lung disorder. See Nicholson statement, Ex. 21, R.35 and following. Litton Ex. 3, p. 4 and following.

Asbestosis usually develops after long exposure to high concentrations of asbestos dust, the risk varying directly with the length of exposure and the dust concentration. Following continued exposure to high concentrations of dust, asbestosis may develop fully in 7 to 9 years and may cause death as early as 13 years after the onset of exposure. The common exposure period before recognition of asbestosis as observed among asbestos workers is 20 to 40 years, with death following about 2 to 10 years later. Once established, asbestosis progresses even after the exposure to dust ceases: illness or death can occur long after exposure to concentrations not producing immediate effects.

The prolonged latency period between exposure and the first signs of asbestosis makes it difficult to establish dose-time relationships.

In 1946, 700 cases of asbestosis were found in Germany among a total of approximately 8,000 employees in the asbestos industry 125 cases of asbestosis of the lung in X-ray examinations of 476 asbestos workers were found in one company in Finland. The occurrence of asbestosis in members of this worker group appears to rise with the duration of the employment: A morbidity of 80 percent among English asbestos workers with over 20 years of employment has been reported. Selikoff and others investigated 1,522 asbestos insulation workers in the New York-New Jersey metropolitan area. Among 392 individuals examined more than 20 years from the onset of exposure, X-Ray evidence of asbestosis was found in 339. In half of these, the asbestosis was moderate or extensive. In individuals with less than 20 years of exposure, radiological evidence of asbestosis was less frequent and when present, less likely to be extensive.

The most common complication of asbestosis is cancer of the lung. However, cancer of the lung apparently induced by asbestos may appear unaccompanied by asbestosis.

The association of lung cancer with exposure to asbestos dust has been the subject of many investigations in recent years and extensively documented in the literature. See Ex. 3, Litton; Ex. 19 Nat'l Acad. and a correlation between asbestosis and lung cancer appears definite.

It is recognized that cancer of the lung produced by asbestos needs further study. The latent period between exposure and evidence of carcinoma may be even longer than for asbestosis. Little is known about the dose-time relationship. Cases of lung cancer have been observed when only a very short exposure or no exposure to asbestos was known. Furthermore, the low number of "asbestos bodies" observed in one-fourth to one-half of the urban population may be sufficient to cause cancer. Because the long "asbestos bodies" remain in the lungs, a person who has inhaled asbestos may carry the potential for the rest of his life to develop carcinoma of the lung. Moreover, it has not been determined whether more than one fiber is necessary to induce a malignant tumor. It has been suggested that the probability of cancer induction is proportional to the number of asbestos fibers, number of susceptible cells, the concentration of carcinogens on the fibers, and the time from exposure.

Why asbestos is carcinogenic is not clearly understood. At least three hypotheses have been advanced:

1. That the fibers act as a physical irritant which after 20 to 30 years of constant irritation induces a tumor.

2. That the fibers contain small amounts of carcinogens, such as benzo(a)pyrene, nickel, and chromium which are eluted from the fibers by the serum in the lungs.

3. That the fibers accumulate in the lung and are immobilized as "asbestos bodies" which disintegrate after 20 to 40 years. The resulting free particles cause asbestosis or carcinoma of the lung.

Primary tumors of the pleura and peritoneum are so rare that for years they were considered to be pathologic curiosities. In 1960 the first large series of cases of diffuse mesothelioma were reported, in South Africa. In trying to explain this mysterious epidemic, "asbestos bodies" were found in the lungs of some of these patients. An association with exposure to the Cape of Good Hope asbestos fields, or the industrial use of asbestos, was established in 32 of 33 patients with histologically proved pleural mesothelioma. The majority of these patients had not actually worked with asbestos but had lived in the vicinity of the mines and mills, and some had left these areas of exposure as young children. The average period between exposure and development of the tumor was 20 to 40 years. Later studies verified this interrelationship between asbestos exposure and mesothelioma. See Litton Report, Ex. 19, p. 12; Nicholson, Ex. 21; Selikoff, Ex. 4.

In an attempt to determine whether mesothelioma of the serosal surfaces was related in any way to asbestos exposure in the United States, Selikoff studied 307 consecutive deaths among asbestos insulation workers in the Northeastern United States. They found 10 deaths caused by four pleural and six peritoneal mesotheliomas. In addition, these workers had a high death rate attributed to cancer of the stomach, colon, and rectum. Of the 307 deaths, 40.4 percent were attributed to cancer, 5.5 percent to asbestosis, and 54.1 percent to other causes. In a second study, the investigators reviewed 26 consecutive autopsies of patients with asbestosis, and found four mesotheliomas of the pleura and three of the peritoneum.

Mesothelioma is now considered a frequent cause of death among asbestos workers. No attempt has been made to summarize the reports of mesothelioma, since they appear almost weekly in the current literature. So far, however, there appear to be few cases among the general population. Selikoff reviewed 31,652 deaths among the general population of over 1,048,183 in the United States and found only three cases of mesothelioma. Moreover, he points out that asbestos is not the only cause of mesothelioma; it has also been produced by silica and polyurethane.

While the exact cause of lung cancer or pleural periotoneal mesothelioma induced by asbestos is not known, air pollution by other pollutants may accelerate the morbidity. One form of air pollution which is easily studied in individuals is smoking. Selikoff recently studied the mortality of 370 asbestos insulation workers. In this group, 24 men died of lung cancer and all had a history of smoking. See Weiss, Ex. 15, "Cigarette Smoking, Asbestos, and Pulmonary Fibrosis", American Review of Respiratory Disease, Vol. 104, 1971. This rate was eight times greater than the expected mortality rate, with age and smoking habits taken into account.

The recent finding of "asbestos bodies" in one-fourth to one-half of the urban population has added new impetus to the examination of asbestos as a general air pollutant.

An "asbestos body" has been defined as "an elongated golden or reddish-brown structure usually with clubbed ends. The shaft, which often shows a segmented or beaded appearance, is usually straight, but sometimes curvilinear with a tendency toward symmetry. Usually it is from 3 to 5 microns in diameter and 20 to 100 microns in length. The coating contains iron demonstrable by

Perle's stain (Prussian blue reaction), and probably composed of ferritin or ferritin-like material. It may cover the structure completely, masking the central fiber from direct view, or may be incomplete in the central portion of the shaft or in the interstices of the body, revealing an expanse of naked fiber.

There is no doubt that the "asbestos bodies" formed in the lungs of the asbestos workers contain asbestos, and it is probable that some are contained in those found in the lungs of the general population.

Evidence that persons other than those working directly with asbestos minerals are being exposed to asbestos is of several types. Asbestos fibers can be demonstrated in the lungs of persons not occupationally exposed. In a few geographic areas, pathologic changes regarded as representing a reaction to asbestos such as pleural calcification have been found in populations with no history of occupational exposure. Asbestos fibers have been demonstrated in ambient air.

Structures that appear to be fibers coated with a pigmented material were described in lung tissue as early as 1907. These structures were actually fibers coated with hemosiderin. Because those who work with asbestos exhibit them a few months after starting work, it was recognized that they were evidence of exposure, but not of asbestosis. The term "asbestos body" came to be the preferred designation.

As long as the coated fibers were found in persons known to have been occupationally exposed to asbestos, the identity of the central fiber was seldom questioned, although from time to time similar objects were found in persons with no known exposure to asbestos.

Identification of the core fibers has proved to be a formidable technical task. Without fiber-by-fiber analysis, all that can be said is that coated fibers resembling those in asbestos workers are present in most persons in our urban centers. Stripping the coating and analyzing the cores by various techniques can sometimes demonstrate that the cores are asbestos, but the process is tedious and often inconclusive. A more appropriate term is "ferrugineous body". Attention is now being directed toward study, not of the ferruginous bodies alone, but of the total fiber content of the lungs, whether such fibers are coated or uncoated.

Evidence is strong that most human lungs harbor thousands or millions of fibers. Some of these are chrysotile asbestos, and other types of asbestos minerals are probably there. In most persons not occupationally exposed to asbestos, the numbers of fibers are relatively small, compared with the numbers found in the occupationally exposed. The systematic application of quantitative techniques, measuring both coated and uncoated fibers, is needed to define a gradient of accumulated fibers for correlation with incidence of disease, on the one hand, and history of environmental exposure, on the other.

Although there appears no doubt that asbestos fibers are present in many human lungs, there are sources of airborne fibers other than asbestos. Some are probably derived from the burning of leaves and plant products, such as paper, wood and coal. Man-made (mostly vitreous) fibers have also been identified in the sediment isolated from human lungs. Talc, often used generously as a dusting powder, may contain a significant amount of tremolite asbestos fibers.

Information is sparse concerning possible increase of fibers in lungs with increasing use of asbestos and concerning the existence of significant differences between urban and rural populations. Selikoff and Hammond compared lung tissues obtained in 1934 and 1967 and found no significant increase in the proportion containing ferruginous bodies. This suggested that, despite increasing use of asbestos in New York City between 1934 and 1967, fibers of a type producing ferruginous bodies had not been increasing at a corresponding rate. Other commentators, however, have noted an increase over each decade in asbestos bodies in samples of lungs from persons who died in London in 1936, 1946, 1956 and 1966.

A review of the literature related to pleural calcification and asbestos exposure strongly suggests an association between pleural calcification and nonoccupational exposures to asbestos. See Nat'l. Acad., Ex. 19, p. 14.

Industrial experience has shown that prolonged inhalation of asbestos can increase the risk of neoplastic (tumor producing) disease. Examination of lung tissue has made it apparent that a much larger proportion of the general public has inhaled and retained asbestos fibers than had formerly been realized; in fact, most urban dwellers have some such fibers in their lungs. The basic issue is whether the general public, as well as persons working near occupational sources, living in the households of asbestos workers, living in the neighborhoods of asbestos plants, or having occasional random exposures, have a detectably increased risk of malignancy or other disease because of airborne asbestos. What information there is to answer these questions comes either from direct epidemiologic studies of groups with various levels of nonoccupational exposure or by extrapolation from the experience of industrial populations with direct or indirect asbestos exposures.

Two general indices of asbestos exposure are available for use in direct epidemiologic studies of groups not known to be occupationally exposed to asbestos. The first is based on knowledge of each member's place of work and place of residence. Because of the long latent periods of asbestos-related disease, this knowledge must cover each person's whole lifetime. The second is a quantitative estimate of each member's lung content of asbestos fibers. There are few such direct epidemiologic studies, and they are inadequate to answer the questions at issue.

Of 42 persons with mesotheliomas reported in Pennsylvania, 10 had worked in asbestos plants, 8 lived or worked close to an asbestos industry, and 3 were members of families that included asbestos workers; in 11, no history of exposure could be obtained, and the remaining 10 had questionable random exposures. On 165 fatal malignant mesotheliomas known to pathologists in Canada between 1959 and 1968, an association was confirmed with occupational exposure to asbestos, but suggests that the excess was in the manufacture and industrial application of asbestos, rather than in mining and milling. It is apparent that no quantitative conclusions were possible from these studies, which present serious methodologic problems to the epidemiologist. They suggest a risk in household contacts and in residence in the immediate neighborhood of asbestos plants. There appear to be different levels of risk in different types of occupational exposures, and some of these may be reflected in corresponding household and neighborhood experience.

Another source of evidence of the relative risks associated with inhaling moderate or small numbers of asbestos fibers is the experience of persons who have had occupational exposures below those known to be definitely hazardous. The maximal airborne fiber concentrations recommended for prevention of asbestosis are much higher than any likely to be encountered in nonoccupational situations. Occupation-related asbestosis can be effectively controlled with airborne fiber concentrations much higher than are likely to be encountered in non-occupational situations. It is important to determine whether workers whose exposures have been reduced to levels that prevent or greatly delay asbestosis, as well as others whose exposures are indirect, have a lower risk of lung cancer than those with higher and more direct exposures.

Most series of case reports of mesothelioma include some persons who have worked in the construction or shipbuilding industries, but in trades not involving direct contact with asbestos. Such persons as plumbers, electricians, and metal workers often have more ferruginous bodies in their lungs than do white-collar workers. A study of occupational groups in California revealed an excess of deaths from lung cancer in insulation workers, but found no excess lung-cancer deaths in other construction trades. There may be a definable gradient of effect within the construction trades. More thorough studies of groups with indirect exposures are certainly needed.

The mortality experience of those who are directly and indirectly exposed to asbestos in their employment is not directly applicable to the general public who have had moderate or slight exposures from ambient air. The evidence suggests a gradient of effect from direct occupational, to indirect occupational, to family and neighborhood situations, in all of which dust concentrations are probably high by comparison with most community air. This suggests that there may be levels of asbestos exposure that will not be associated with any detectable risk. What those levels are is not known. However, if we eliminate the known occupational, household and neighborhood exposures, we drastically decrease the potential for this risk. For this reason our regulations must be directed to emission sources and limitations imposed at the origin as distinguished from an effort to establish air quality standards as we have done with regard to other air pollutants of demonstrated adverse health effects.

Having considered the health impact inherent in asbestos emissions, we now examine the available measurement and abatement procedures.

Sampling of asbestos fiber seeks to obtain a representative sample of the total air mass in sufficient quantity to make quantitative assessments statistically significant. Methods employed in asbestos sampling and the possible sources of error are discussed at length in Ex. 20, Harwood, p. 42 and following.

Of the several techniques available for emission sampling, the membrane filter recommended by the U. S. Public Health Service, has become the standard technique for environmental asbestos emission sampling.

Air is drawn through a cellulose membrane filter where the particles are entrained. Although the effective pore size of the filter (0.45 microns to 0.8 microns) is larger than the diameter of many of the asbestos fibers, the surface charge properties of the filter and the asbestos fibers, plus the circuitous path through the filter, result in collection of virtually all of the particles and fibers to which the filter is exposed.

The collected fibers must be analyzed. This may be accomplished by using a microscopic, photographic or electronic technique to count the fibers resulting from a known volume of air. The fibers which are counted are seen at a given magnification and the number will vary.

The standard practice in industrial hygiene is to use a phase contrast microscope at a magnification of X430. The fibers counted are those having a length of greater than 5 microns with the ratio of length to breadth at least 3:1.

The use of an electron microscope would allow all the particles to be counted, However, the expense, time and expertise necessary to count all the particles makes this procedure impractical.

In understanding control techniques and their efficiencies, it is important not to confuse efficiencies quoted on a weight basis with those based on a particle count.

Considering efficiency based on a weight basis, it is relatively easy to get a very high efficiency with particles whose size is in excess of 5 microns with a variety of control devices. However, the efficiency does drop off considerably with decrease of particle size.

Dr. Harwood, in his study, considers what a collection efficiency as high as 99.999% (the percentage of the total weight of the particulate matter which will be collected by the filter) actually means in terms of the number of fibers collected. (Ex. 20 , p. 47). He concludes that 10^7 fibers actually will pass through the collecting filter for every 1 gram of material impinging upon it.

This is a situation not frequently brought out, but is very significant when exposure levels are monitored in terms of fibers per cubic centimeter. Thus, quoting of efficiency in terms of mass efficiency is a statement that tends to be deceptive. It bears no obvious relation to the number of fibers being emitted.

However, based on tests which actually measure the number of fibers being emitted, it would seem that both fabric filters and high efficiency wet scrubbers are capable of reducing the fiber counts to acceptable levels. British experience is that 0.2 f/cc is routine and Johns Manville finds that 1 f/cc is an acceptable value when the results are averaged over a time period.

We adopt the two fibers per cubic centimeter and the over five micron standards because of the facility of both abatement and measurement utilizing these numbers and because they furnish a sound indication of asbestos content in the air. However, recognition that particles of smaller size may have adverse health consequences of equal or greater magnitude will require the Board to review this subject periodically in consideration of the available measurement technology. See Ex. 6, Lynch, Ayer and Johnson, "The Interrelationships of Selected Asbestos Exposure Indices,"American Industrial Hygiene Association Journal, September-October, 1970, p. 598. (The direct index of asbestos fiber exposure proved to be the concentration of fibers longer than 5 microns. See Ex. 27, Edwards and Lynch, "The Method Used by the U. S. Public Health Service for Enumeration of Asbestos Dust on Membrane Filters," U. S. Department of HEW.

Consideration must be given to available control techniques, the fabrication and use of asbestos containing products and exposure resulting from activities involving asbestos emission potential.

Because of the demonstrated alternatives to asbestos spraying, our regulations will flatly outlaw this activity. Spraying of non-asbestos materials are permitted subject to stringent protective measures.

Air ventilation systems can be employed to minimize emission during the mixing of fibrous fireproofing and insulation materials. Hoods can be provided at bag-opening and emptying areas. The mixing area, if not totally enclosed, should be ventilated. Conveying equipment, to and from the mixer, can be enclosed. Bagging of the mixed material should be done under suction hoods.

On-site controls needed include enclosing the area to be sprayed and employing good housekeeping procedures both before and following the spray operation. The filling of the spray machine hopper must be done carefully to minimize dust. When the machine is not in use, the hopper should be covered to prevent the material from being blown about.

Several states and manufacturing associations have published guidelines for emission control. The recommendations include the following:

1. All areas used for opening bags containing fibrous insulating materials and charging of hoppers should be enclosed. Empty bags should be properly disposed of.

2. Floor areas should be swept broom clean before spraying operations begin. All unnecessary objects in the spray area should be removed or covered with plastic or plastic coated tarpaulins.

3. The entire area to be sprayed should be enclosed with plastic or plastic coated tarpaulins. An enclosure will be considered satisfactory only if visible insulating material cannot escape from the closure.

4. Fibrous-containing material that falls to the floor should be swept up immediately and placed in approved disposable containers.

5. When spraying is completed in an area, the entire work area and the materials used to form the enclosure should be thoroughly vacuumed. The vacuum cleaner should contain a strong, single-service, disposal inner bag which shall be removed from the vacuum cleaner and sealed. Disposal is the same as for other bagged waste materials.

6. Any plenum or other structure coated with asbestos-containing insulation and intended for circulation of air in the building must be thoroughly cleaned of debris and waste. Fibrous insulation in a duct or plenum must be coated with a sealer to preclude erosion of the insulation by circulating air.

Our regulations embody the essential features of these suggestions.

Asbestos emissions are likely in any process in which asbestos fiber is handled or asbestos-containing materials are cut, drilled, or trimmed. The quantity of asbestos dust generated by these operations can be quite large. Since it is impractical to completely seal a factory or a work area, industry has adopted an arrest-at-the-source technique for capturing this dust utilizing a complex ventilation system comprised of capture hoods, ductwork, fans and filters. Benefits received from this system include:

1. Reduced atmospheric emission when plant is open to ambient conditions (i.e., doors and windows open).

2. Reduced external emission from fibers being carried outside on work clothing and manufactured products.

3. Greater efficiency in plant operation because of reduced internal housekeeping chores (vacuuming, etc.).

4. Better personnel attitudes. The ventilation system may eliminate the need for personal respirator units which limit efficiency and are generally disliked by workers.

The air ventilation system is an integral part of the emission control program and the components of various systems in operation will be considered.

Two types of ventilation systems are employed for dust emission control; low volume, high velocity; and high volume, low velocity. Each requires a specific type of hood design.

The low volume, high velocity systems induce an extremely high captive air velocity, 10,000 to 12,000 ft/min., at the dust source. The air volume, however, averages only 10-250 cfm. With this system it is essential that the feed particles be carried by the air stream. The entrainment force must exceed the gravitational or projectional force.

Low velocity, high volume air ventilation systems, on the other hand, are utilized for operations where localized capture is not possible. For such hoods to be effective, the air velocity to the ducted area must be at least 150 ft/min and should be such that the air flow direction is always toward the collection system.

A considerable amount of ductwork is required for a large plant having a central collection point. Circular ducts, having no sharp bends, are recommended. Inspection ports should be provided near bends.

Several types of collectors have been utilized by the asbestos industry for dust control. Baghouses represent the most frequently used filtering system. Wet scrubbers are also used. Cyclone precipitators may be used as primary collectors preceding baghouse filters.

Electrostatic precipitators tried by the asbestos industry have several deficiencies. Asbestos is an insulator and builds upon the electrodes reducing efficiency. Installation costs are higher than for baghouses. An electrical failure would remove all emission control.

The most commonly used filter system is the fabric filter. This device is found in a wide variety of forms from highly sophisticated systems containing thousands of bags to crude devices containing homemade burlap bags. The baghouse is compartmentalized to allow continuous operation by alternately cutting off sections for cleaning while other sections continue their dust removal function. The bags are "cleaned" by a mechanical shaking action, either by a shaking floor or, more commonly, by a shaking support. More elaborate cleaning systems such as reverse cycle air jets or sonic systems have not been considered worth the extra complication.

The baghouse unit is frequently located outside the factory building to conserve space. Usually the filtered air is exhausted to the atmosphere. In some cases it is returned to the factory to conserve heat. This air contains some asbestos fibers since no control technique is considered to be 100% efficient. Waste products collected in the baghouse hoppper are removed by helical screw conveyor. Design of the hopper emptying mechanism should provide as foolproof an operation as possible. Severe pollution can arise if the mechanism is opened for repair.

Other collection devices used either in combination with fabric filters or alone are various types of cyclone separators.

Low efficiency cyclones are used in the asbestos industry as first stage separators preceding fabric filters. They are useful when the waste product is reusable and there is a considerable quantity present. Thus, the load on the fabric filter is relieved.

Further, the removal of heavy abrasive waste material will prolong the life of the filter bag.

High efficiency cyclones are generally employed in multiple units. They are used where high efficiency is required and where no use is made of backup fabric filters.

Wet cyclones are employed as emission control devices in some special instances where wet processes are used for production of asbestos products. Although generally not as efficient as bag filters, they eliminate the problem of filter blockage caused by condensation.

The fans which provide the air movement through the dust collection system may be mounted either upstream or downstream of the filter system, the most common arrangement being downstream. This places the ventilation system under a negative pressure assuring that ambient air will be drawn into the system in case of leaks, rather than dust and fibers being exhausted to the atmosphere.

All asbestos product manufacturers are faced with the problems of storage and transportation of bagged asbestos fibers. Emission controls for these operations depends to a great extent upon the conscientiousness of the individual user.

Manufacturers should provide clearly defined, clean, dry storage space for the bags where they are protected from accidental damage. A rotation system should be employed to ensure that older bags are used first. Damaged bags should be placed in larger slipover bags and resealed. Small tears in bags should be patched with tape.

Jute bags are permeable and will allow fiber emission. Kraft paper bags are liable to tearing when handled roughly. The best compromise at this time seems to be bags of coated, woven polyolefin.

Bag storage and the bag opening areas should be as close as practical. Fork-lift trucks are usually employed to transport the bags between these areas. The route used by the trucks should be smooth surfaced and free of obstructions which might cause damage to the bags.

The bags should be opened in a hooded area using a sharp knife to slit the bag. Pressure packed fibers will hold together as a unit and can be slipped into an enclosed conveying system where they are transported to a fiber opener (willow or fluffer). All conveyor systems transporting asbestos fibers or mixtures of asbestos and other materials must be completely enclosed.

The emptied bags also present an emission source. Care must be taken to dispose of them. Since there are few manufacturing processes which will accept paper bags as part of the process, asbestos paper being an exception, they are usually bundled into large polyethylene bags and taken to dumps for disposal. Plastic shipping bags can be similarly utilized in some manufacturing processes as the floor tile industry, for example.

A possible source of emission from manufacturing processes is the transport of fibers outside by the workers themselves. The control of this source of emission to date has not been very satisfactory. At best, booths are provided where workers may clean fibers from their clothing. The booths are equipped with extraction fans in the ceiling and a flexible pressure hose. Suction hoses would be preferable. Separate lockers for work and street clothing is suggested. See Ex. 9, Cralley, "Identification and Control of Asbestos Exposures", American Industrial Hygiene Association Journal, February, 1971, p. 82. Ex. 18, "Recommendations for Handling Asbestos", Engineering Equipment User Assn., No. 33, Rev. 1971. Ex. 13, "Recommended Health Safety Practices", National Insulation Manufacturers Association, Inc.

Demolition and waste disposal are likely to be emission sources if appreciable amounts of asbestos are used in construction, unless operational procedures are strictly controlled. Isolation, enclosure, and wetting down are useful. Caution must be observed not to demolish during high winds and to keep sludge from drying out and becoming airborne later through natural forces and from being introduced into sources of drinking water.

The subject of disposal of asbestos waste must be examined. Recycling is possible if a plant has a filter-ventilation system. But the effectiveness of recycling varies with the kind of processing. If a product such as water pipes is made in which asbestos is mixed with cement, a chemical reaction occurs making re-use of much waste impractical or impossible. If asbestos paper is produced, much airborne fiber can be collected and re-used. However, virtually all manufacturing of asbestos products can involve some recycling.

The dust collected in the filters, the "short fibers", can be reused in the manufacturing of transite pipe. This pipe contains mostly long fibers used for their strength and thus, only a limited amount of the "shorts" can be mixed in. Recycling is especially feasible for large companies which manufacture transite pipe as well as other asbestos products. In this case, recycling is profitable as it involves only cleaning the filters and transporting the "shorts" in the area of the plant or to the division of the company which manufactures transite. Recycling does not appear to be relied upon as much in plants which do not produce transite. In such case, the company would have to sell its short fibers. We do not know how great the demand is. Nor do we know the percentage of collected fibers which can be recycled under optimal economic conditions. Johns-Manville in Waukegan claims to re-use "most" of the filtered short fibers. But it manufactures transite, brake linings, sheet packing and gaskets, which facilitates and makes cheaper the use of captured fibers in transite production.

Generally, the asbestos collected through the filters or swept up is disposed into plastic bags. A special disposal procedure is followed by some manufacturers of asbestos paper products. Water is used in the production, which picks up asbestos fibers and is then drained off into settling ponds. The heavy material settles out and the water is then channeled back to the plant for re-use. The sludge is at the bottom of the pond and is shovelled up and dumped. The material is not buried.

We do not know if any factory directly or eventually discharges this water into natural water flows or sewage systems, which could pose a considerable hazard. The Johns-Manville Waukegan plant uses a pond system, but the water is recycled.

While our regulations are enacted in the context of other governmental controls of asbestos, they necessarily go beyond these regulations to deal with significant emission sources not covered elsewhere.

The Federal Environmental Protection Agency proposed asbestos standards on December 7, 1971, under its authority to regulate hazardous air pollutants (40 CFR, Part 6). All emission sources which exist in Illinois and which are proposed for coverage by the Federal Environmental Protection Agency are covered by today's regulation. Also, our regulation covers waste disposal and water pollution; imposes procedural safeguards for construction and demolition; and sets a numerical emission standard in addition to a "no visible emission" standard for manufacturing emissions beyond the plant.

The Illinois Department of Labor adopted the recommended safety standard of the American Conference of Governmental-Industrial Hygienists for "in-plant" air. The regulation we adopt today does not control the levels of asbestos inside a plant, largely an occupational hazard beyond our jurisdiction. Insofar as this Board's regulation affects what transpires inside a plant or on a construction site, the impact is merely incidental to the relationship between certain "in-plant" activity and a significant hazard of air pollution beyond the site of such activity.

For example, Sec. 201(c) requires that facilities be provided at the work site to prevent the removal of visible amounts of asbestos from the site on the clothing of employees. The evidence shows that human transport of asbestos fiber is a health hazard to those coming into contact with asbestos workers beyond the confines of the job.

The Illinois Department of Labor also adopted procedures for enclosure and cleaning of construction sites, on which asbestos is sprayed. These procedures were intended to protect the health of workers on the site, although their effect, if pursued, would be to reduce emissions to the ambient air. The record shows that such procedures are cumbersome, seldom obeyed to the letter, difficult to enforce and insufficient when obeyed to protect the public beyond a construction site. Hence, we have banned asbestos spraying. Again, the impact which this Board's decision exerts on the actions of another state agency is made necessary by our mandate to protect all members of the public from air pollution.

A similar ban on spray asbestos has already been taken by the Cities of Chicago (effective January 1, 1972), and New York, and is being considered by several other cities.

In consideration of the foregoing factors, the Board submits a comprehensive regulation for asbestos controls. To this end, the regulations identify the significant contributors of asbestos as the commercial use of asbestos in construction work; the demolition of asbestos-containing structures; the manufacturing and processing of asbestos-containing products; the transportation of certain asbestos-containing products; and the disposal of asbestos-containing waste. The use of asbestos in brakes, while originally included as a subject of control, will be deferred for the time being.

Part II of the regulations imposes several general requirements upon all commercial construction, repair, alteration, demolition, manufacturing or processing activity from which asbestos fiber is discharged into the ambient air. The persons responsible for manufacturing activity must obtain a permit from the Environmental Protection Agency. The permit system will serve to produce the advanced assurance of compliance with the applicable control regulations and will thus reduce the cost and burden of in-the-field enforcement.

In addition, these commercial activities must provide facilities to prevent the removal of asbestos fibers from the site of such activity on the clothing of employees. Indeed, this poses a rather new concept of air pollution control. Those who have died from lung ailments induced by long, close association to an asbestos worker may be powerful proof of the need for novelty.

Finally, the Regulation would provide for careful waste disposal procedures, as wind-blown refuse heaps and scrap piles contribute to the volume of asbestos fiber in our air. The simple steps for control eliminate any excuse for such dangerously sloppy housework.

In our final draft, the permit requirement of Part II has been restricted to manufacturing emission sources. This is in accord with the Agency testimony that presently it has inadequate staff to handle the permit load created by a blanket requirement. All manufacturers of asbestos products must obtain a permit by June 30, 1972.

Part III prohibits the spraying of asbestos-containing insulation and fireproofing. Experience has indicated that procedural safeguards are inadequate and their enforcement is an overtaxing burden.

Procedural safeguards designed to reduce fiber emissions would be required to spray non-asbestos insulation. The biological effects of these fibers is unknown. Prudence would seem to dictate reasonable efforts to soften the potential future blow from spray fiber aspiring to asbestos' status.

Part III requires that various asbestos-related activities at construction sites be done within an enclosure. It would also require that asbestos construction products be so installed as to preclude the emission of fiber into the circulating air.

In the interest of efficient enforcement the numerous restrictions on the spraying of non-asbestos fibrous material have been reduced to requirements for enclosure and for vacuuming. Also this section has been changed to make clear that these safeguards are required only when spraying of non-asbestos materials occurs in an area open to the atmosphere. This "open to the atmosphere" modification has also been added to the section controlling the cutting, trimming, fitting or stripping of asbestos-containing materials at a construction site. Part III now contains a "no visible emission" standard which must be met regardless of adherence to the required procedural safeguards. This should permit easier enforcement and tend to insure greater compliance with the safeguards.

The original proposal contained two regulations controlling the general application of asbestos-containing materials and the application of non-asbestos materials in air ducts or plenums. This has been altered to require that only asbestos-containing materials, used in any construction work, be so installed as to preclude emission of the fiber to the circulating air. There is little medical data available to prove or disprove the toxic effects of the multitude of non-fibrous construction material, although one such product, fiberglass, would appear to be biologically inert. The Board prefers to act on the safe side of health in regard to spraying operations, which can emit large quantities of fiber if uncontrolled. In any event, such uncontrolled emissions constitute a nuisance dust and could be controlled on that basis alone. These reasons do not apply with equal force to the non-spray application of non-asbestos materials in construction.

Part IV expresses, ironically, what may be a key reason for banning spray asbestos. It would require that procedural safeguards be pursued in order to demolish a structure whose destruction would otherwise expose members of the public to asbestos fiber. Clouds of dust are often raised by demolition work. The fact that great numbers of persons may be exposed to this dust in urban areas and that the post-war generation of high-rises were the first buildings to use asbestos insulation extensively speak in favor of such regulation.

Part IV is intended to require an enclosure only when necessary to prevent dispersion of dust during demolition and only an enclosure which is reasonably compatible with the structure to be demolished. In some cases, total enclosure can be feasibly achieved. With other structures, a ground level enclosure may be the limit of compatibility.

Part V, controlling manufacturing sources, is changed to require an emission standard of two fibers per cubic centimeter and no visible emissions. While some testimony indicated the difficulty in measuring compliance with a numerical emission standard, overall, the evidence establishes both the need (protection against the great proportion of invisible fiber) and the ease of measurement of such a criterion. A "no visible emission" standard has been added to the numerical standard to simplify enforcement against exceptionally dirty emission sources. A grace period, until June 30, 1972, has been added to permit acquisition of the necessary control equipment to attain the emission standard.

References are made to the method to be used in collecting and counting emission samples. The sampling method is that generally used in sampling particulate emissions. The counting method is that reliably used by the U. S. Public Health Service.

A requirement has been added, at the Environmental Protection Agency's suggestion, to channel all asbestos emissions inside the plant through control equipment and to exhaust such emissions through points where samples can be taken. This is intended to prevent venting through windows or doors or other avenues of escape on which sampling cannot be adequately performed. The Agency is also given the power to inspect manufacturing premises at reasonable times to determine compliance. Also, the manufacturer must engage in monitoring and reporting. The latter two additions are in keeping with the Board's practice in most areas of regulation.

The waste water discharge provision now requires no discharge of process water to which the manufacturer has added asbestos unless best available treatment technology is first utilized.

A "no visible emission" standard has been added to the transportation regulation.

The emission standard would measure only fibers longer than five microns. The justification for this seems to be the adminis trative convenience of avoiding difficulties in measuring fibers from .5 to five microns in length. Some medical evidence has indicated that the very small fibers may be the most dangerous. The Board will continue to examine the medical implications of the sub-five micron fibers and the means of measurement and control.

Part V, Sec. 501(a) - has been slightly changed from the proposed final draft to add the phrase "into the ambient air" in order to make clear that the emission standard does not apply to the in-plant atmosphere.

In Part V, Sec. 502 - the word "enclose" has been changed to "control" on the suggestion that as previously written the meaning was unclear and implied total enclosure of all facilities.

Our original proposal would have prohibited the use of brake lining in vehicles manufactured after January 1, 1975 and sold for use in Illinois. It was believed if brake lining decomposition emits asbestos fiber, then the tremendous number of vehicles using asbestos, and the impracticability of controlling these numerous small emission sources would appear to speak to the need for a product ban.

This proposal to ban asbestos brake lining has been dropped for the time being. While the evidence shows that brake lining decomposition is a significant source of background levels of asbestos, these ambient air levels are quite small and have not been shown to be a health hazard (although they have not been shown not to be). In addition, adequate alternatives to asbestos-lined brakes are not yet available, although closed braking systems, preventing the emission of asbestos dust,are possible. The Board will follow the medical and engineering aspects of this problem and possibly may return to it.

Finally, local governments are obliged to enforce these regulations, except for the manufacturing provisions. Much of the problem arises from numerous construction activities, and the Agency cannot adequately supervise these many emission sources. The "no visible emission" standard has been added especially to facilitate local government and citizen assistance in enforcement.

I, Christan Moffett, Clerk of the Illinois Pollution Control Board, certify that the above Opinion was adopted on the 6th day of January 1972 by a vote of 4-0.

Christan Moffett