

A STUDY OF AIRBORNE ASBESTOS
FIBERS IN CONNECTICUT

by

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ABSTRACT

The following discussion describes actions taken by the Connecticut Air Compliance Unit for the purposes of studying the danger to public health associated with excessive airborne asbestos fiber concentrations.

In Connecticut, the criteria of mesothelioma was selected as the basis for developing an ambient air quality standard for asbestos (i.e., 30 ng/m³ or 30,000 fibers/m³, 30 day average) and compatible mass emission standard (i.e., 24 g/day) in lieu of EPA's qualitative asbestos regulations. An ambient air asbestos survey indicated that asbestos concentrations contiguous to manufacturing sources of asbestos emissions exceed Connecticut's proposed standard. Furthermore, asbestos levels adjacent to toll plazas were also elevated relative to levels removed from manufacturing sources implicating vehicle brake lining decomposition as a significant source of airborne asbestos fibers. In addition to the aforementioned air asbestos survey, a preliminary study of mesothelioma was conducted. There were 133 Connecticut residents diagnosed with mesothelioma between 1935 and 1972. Although subject to diagnostic error, available statistics suggest that the combined sex age-adjusted mesothelioma incidence rate (AAR) per 100,000 Connecticut population has exhibited a possible 10-fold increase since 1935, rising from 0.02 during 1940 to 0.25 from 1960 to 1969. The trends for both men and women also showed sharp increases over the same time period (1940 to 1970). The rapid rise in Connecticut's mesothelioma incidence rate closely follows the increase in the State's cumulative asbestos consumption and suggests a linearly increasing cause-effect relationship which warrants further investigation.

INTRODUCTION

In 1973 the federal EPA, recognizing the need to control the emission of asbestos fibers into the ambient air, promulgated National Emission Standards for Hazardous Air Pollutants (NESHAPS) - asbestos, mercury and beryllium.^{1,2} After an extensive review, Connecticut's Air Compliance Unit found EPA's asbestos regulation to be inadequate for the purposes of protecting public health in Connecticut and, consequently, developed its own asbestos regulation.^{3,4} While EPA's asbestos regulation was written in rather general terms (i.e., "...no visible emissions or application of the best available control technology..."), Connecticut proposed a numerical ambient air quality standard of 30 ng/m³ or 30,000 total asbestos fibers (determined by electron microscopy) per cubic meter of air, 30-day average, and a compatible mass emission standard of 24 g/day at public hearings held in July of 1973. In the judgment of the Connecticut Air Compliance Unit a "no visible emission" asbestos air quality standard does not provide the State's residents with an adequate degree of protection from this carcinogenic substance. In addition, Connecticut also proposed to more stringently control the demolition of asbestos-containing structures.

In order to define the magnitude of the environmental hazards posed by airborne asbestos fibers in Connecticut, prior to the promulgation of the State's asbestos standard, the Air Compliance Unit conducted an ambient air asbestos survey along with a study of asbestos-induced mesothelioma incidence.^{5,6} The following discussion describes actions taken by the Connecticut Air Compliance Unit for the purposes of studying the danger to public health associated with excessive airborne asbestos fiber concentrations.

SOURCES OF AIRBORNE ASBESTOS FIBERS IN CONNECTICUT

Outdoors, the principal source of airborne asbestos fibers in Connecticut is the manufacture of the many asbestos-containing products (e.g., friction products, gaskets). It is estimated that almost 10 tons of asbestos fibers might be released into the Connecticut atmosphere annually as a result of manufacturing operations, assuming reasonably efficient (i.e., 95% asbestos removal efficiency or greater) control equipment is employed. Another major source of airborne asbestos fibers is the erosion of asbestos-containing brake linings and clutch facings. This accounts for approximately 2 additional tons of airborne asbestos fibers each year.^{3,4} Notwithstanding EPA's current regulations covering the demolition of asbestos containing structures, perhaps the largest potential future source of asbestos emissions might be the demolition of buildings which have been insulated and/or fireproofed with asbestos materials. The portion of the NESHAPS regulation pertaining to the demolition of asbestos-containing structures does not clearly state what requirements a demolition operator must meet in order to ascertain whether a structure to be demolished does or does not contain friable asbestos materials. The inherent difficulty in determining whether a building to be demolished contains any asbestos materials and the

associated costs involved in removing such materials if present necessitate some type of formalized testing procedure. Briefly, such a test might entail taking samples from the walls, insulation covering load-supporting structural members and the floor and ceiling tile, from at least one floor of the candidate structure, in addition to the insulation covering the boiler and pipes. A composite sample could then be created and analyzed to determine its asbestos content using relatively inexpensive techniques (X-ray diffraction). It is important that the asbestos content of floor and ceiling tiles be ascertained since these non-friable asbestos materials might be pulverized during the demolition of a structure creating a potentially serious asbestos air pollution problem, especially if the technique known as "explosive demolition" is used. The amount of asbestos fiber dust released into the outdoor air during the demolition of an asbestos-containing structure is unknown at this time, but would appear to be potentially large since there are over 2,000 demolitions in the State each year, and should thus be quantified as soon as possible.

Indoors, many do-it-yourself home projects create asbestos dust due to the mixing of dry, loose asbestos with water and subsequent application of such mixtures for the purposes of insulating and/or fireproofing boilers, pipes, etc..., and the cutting and sawing of asbestos-containing wallboard, ceiling and floor tile. Perhaps the more serious public health hazard posed at this time by excessive asbestos fiber exposure has been created by the release of asbestos fibers from asbestos-containing surface coatings, which were applied indoors to walls, ceilings, exposed structural steel, air ducts, plenums, return air spaces, for insulating, decorating and fireproofing purposes indoors. As a result of such activities appreciable amounts of asbestos fibers may be released into the air indoors, during the application, again as the surface coating deteriorates, and finally, when the building is demolished. The asbestos fibers resulting from the spraying operation itself, as well as those released from the coating over a period of time due to its friable nature, should be of primary health concern. At least one state (i.e., New Jersey) and one local municipality (i.e., New Haven, Connecticut) have already promulgated regulations for the purposes of controlling and/or prohibiting the future use of spray-on asbestos surface coatings indoors. NESHAPS currently prohibits the use of such asbestos-containing spray-on insulation and fireproofing materials outdoors; a recent amendment to NESHAPS proposes to prohibit the future use of any type of spray-on asbestos coating indoors.⁷

AMBIENT AIR ASBESTOS STANDARD

The approach taken in developing Connecticut's proposed ambient air quality standard for asbestos was to derive a numerical standard which should not be exceeded at this time. In other words, all assumptions were made such that the standard could not be criticized as being too strict. Setting standards should be viewed as a dynamic process in that any value must be reviewed and revised periodically as additional pertinent information becomes available. Even a preliminary air quality

standard is valuable because it provides some quantitative idea as to what health risk is associated with varying pollutant levels. Such a standard can be especially useful in developing a set of priorities for correcting environmental problems created by certain pollutants. For example, areas which are well below the standard need no immediate attention, while areas well above the standard require that some sort of corrective action be taken as soon as possible. Such an approach is particularly needed for toxic multi-media environmental pollutants, such as asbestos. In this manner limited resources can be effectively directed at solving the more serious aspects of the problem and, at the same time actions based solely on emotional decisions by poorly informed administrators can be minimized. Connecticut's proposed asbestos standard should be viewed in this light; i.e., this standard is a first attempt at quantifying the adverse health effects posed to the general public by excessive airborne asbestos fibers. Hopefully, any questions raised by the rationale used in developing this standard will be answered by future studies using varied approaches.

Mesothelioma incidence was selected as the foundation for developing Connecticut's proposed air quality standard for asbestos for the following reasons:⁸⁻¹⁰

- *The high frequency of lung cancer in the general population makes it difficult to relate a given case of bronchiogenic carcinoma to asbestos exposure with the high degree of probability that exists for mesothelioma.
- *Some investigators suggest that the smaller asbestos fibers (i.e., those less than 5 μ in length) most likely encountered in the ambient air may be incapable of inducing lung cancer, however, it has not been demonstrated that these shorter asbestos fibers are incapable of producing mesothelioma.

Most of the information available on the adverse health effects caused by excessive asbestos fiber exposure has been collected in occupational environments (Table 1).¹¹⁻¹⁷ Unfortunately, quantitative dose-response relationships concerning environmental asbestos exposures and mesothelioma incidence in different industrial settings are not available. In 1973, the National Institute for Occupational Safety and Health (NIOSH) monitored asbestos concentrations in a number of occupational environments.¹⁸ While these short-term fiber concentrations are of recent origin and, therefore, cannot be directly related to epidemiological studies of mesothelioma incidence, they can be used to obtain an estimate of the range of occupational asbestos exposure likely encountered in different industrial settings. For example, Selikoff and co-workers reported that for workers in the construction industry (followed for 20 years or longer) 0.63% contracted mesothelioma.¹⁵ The variation in asbestos fiber exposure for the construction industry from the NIOSH study ranged from

Table 1. Incidence of mesothelioma and asbestos concentrations in occupational environments.¹¹

Industry	Cohort ^a Number of individuals	Meso- thelioma incidence %	Reference	Highest ^b average concentration fiber/ cm ³	Lowest ^b average concentration fiber/ cm ³
Insulation plants	689	2.18	(11)	74.4	0.1
Shipyards	3000	0.73	(11),(14)	8.7	0.3
Construction	632	0.63	(11),(15)	7.1	0.9
Textile plants	716	1.50	(11),(13)	29.9	0.1
	1300	1.00	(11),(13),(16)	29.9	0.1
	~1300	1.20	(11),(12),(17)	29.9	0.1

^a Most of the individuals in these studies had been followed for 20 years or longer.

^b Concentrations for NIOSH document.¹⁸

0.1 to 29.9 fibers/cc which corresponds to a hypothetical probability of contracting mesothelioma of 63/10,000 (i.e., 0.63%). In a like manner, occupational mesothelioma incidence (provided by studies appearing in the open literature) and corresponding estimates of the range of asbestos fiber exposure (provided by the aforementioned NIOSH report) were used to construct a first generation occupational asbestos fiber exposure-mesothelioma incidence envelope (Figure 1).

Only asbestos fibers greater than 5μ in length with an aspect ratio of 3:1 (as viewed by phase contrast light microscopy; 430x magnification) are monitored in industrial environments. These longer asbestos fibers account for approximately 2% of all asbestos fibers present (by number).¹⁹ Expressed in another manner, there are 50 asbestos fibers for every 5μ size fiber. Furthermore, it has been estimated that there are approximately 1,000 asbestos fibers per nanogram of asbestos.^{3,20,21} Consequently, 20 "industrial size" asbestos fibers are equivalent to approximately one nanogram of asbestos. Other investigators have reported similar relationships between industrial size asbestos fibers, total asbestos fibers and their weight equivalents.^{3,19} In addition, occupational exposure concentrations based on a 8-hour day, 5-day week should be related to general population ambient exposure levels. This can be accomplished by dividing occupational concentrations by 4.2 (i.e., 24-hour/8-hour x 7 day/5 day = 4.2).²² Now the occupational mesothelioma incidence envelope depicted in Figure 1 can be converted to a general population mesothelioma incidence envelope (as a function of both weight and number of asbestos fibers per volume of air), from which an ambient air quality standard for asbestos can be selected (see Figure 2). Using the minimum line a level of 30 ng/m³ or 30,000 fibers/m³, which is projected to induce 150 mesotheliomas nationwide or 2 in Connecticut, was chosen. The use of the minimum line, which reflects the smallest probability of an individual contracting mesothelioma for a given exposure level, is consistent with the aforementioned objective of developing an asbestos standard which would be difficult to criticize as being too strict; the use of either the maximum or some average line would have yielded an asbestos standard some 2 orders of magnitude more restrictive (lower) than the proposed standard for the same response. The chosen standard should result in about 1/10 the yearly fatalities from airplane accidents and approximately the same number of deaths as from train mishaps (see Figure 3).³

The subject asbestos standard is equivalent to an occupational asbestos level of 0.0025 fibers ($>5\mu$)/cc, well below the newly proposed occupational standard of 0.5 fibers ($>5\mu$)/cc.²³ This strongly suggests that the aforementioned proposed occupational asbestos standard is not yet low enough to adequately protect the worker exposed to asbestos fibers from contracting mesothelioma.

Connecticut's ambient air quality standard for asbestos is based on a 30-day average sampling period instead of the more common 24-hour duration because a 1-month averaging time is more manageable from a

Figure 1. Expected Incidence of Contracting
Mesothelioma as a Function of Industrial Air
Asbestos Exposure (8 Hr Day, 5-Day Week)

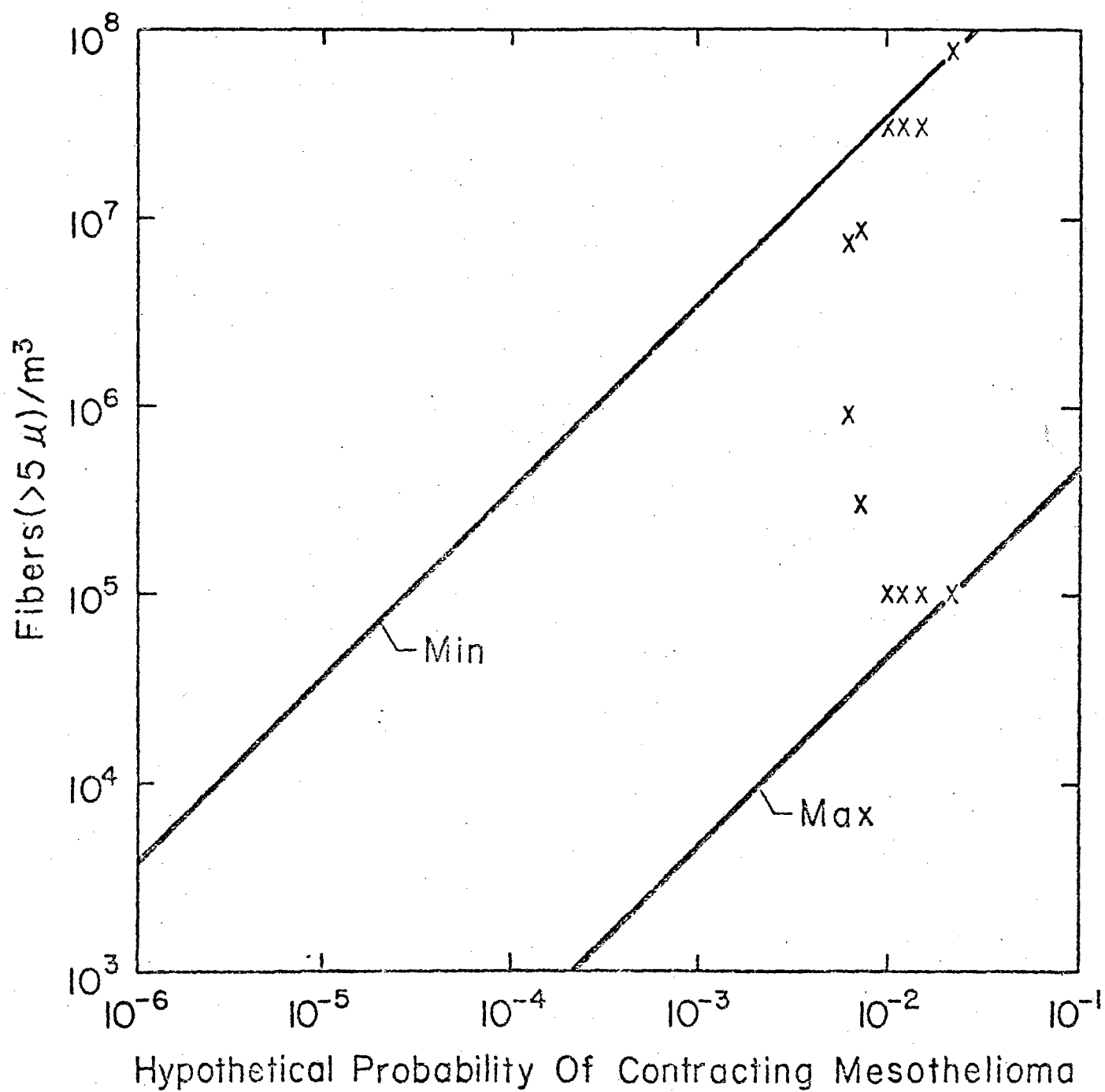


Figure 2. Nationwide Expected Cases of Mesothelioma
As A Function of Ambient Air Asbestos Exposure
(Assumed Population of United States was 230 Million People)

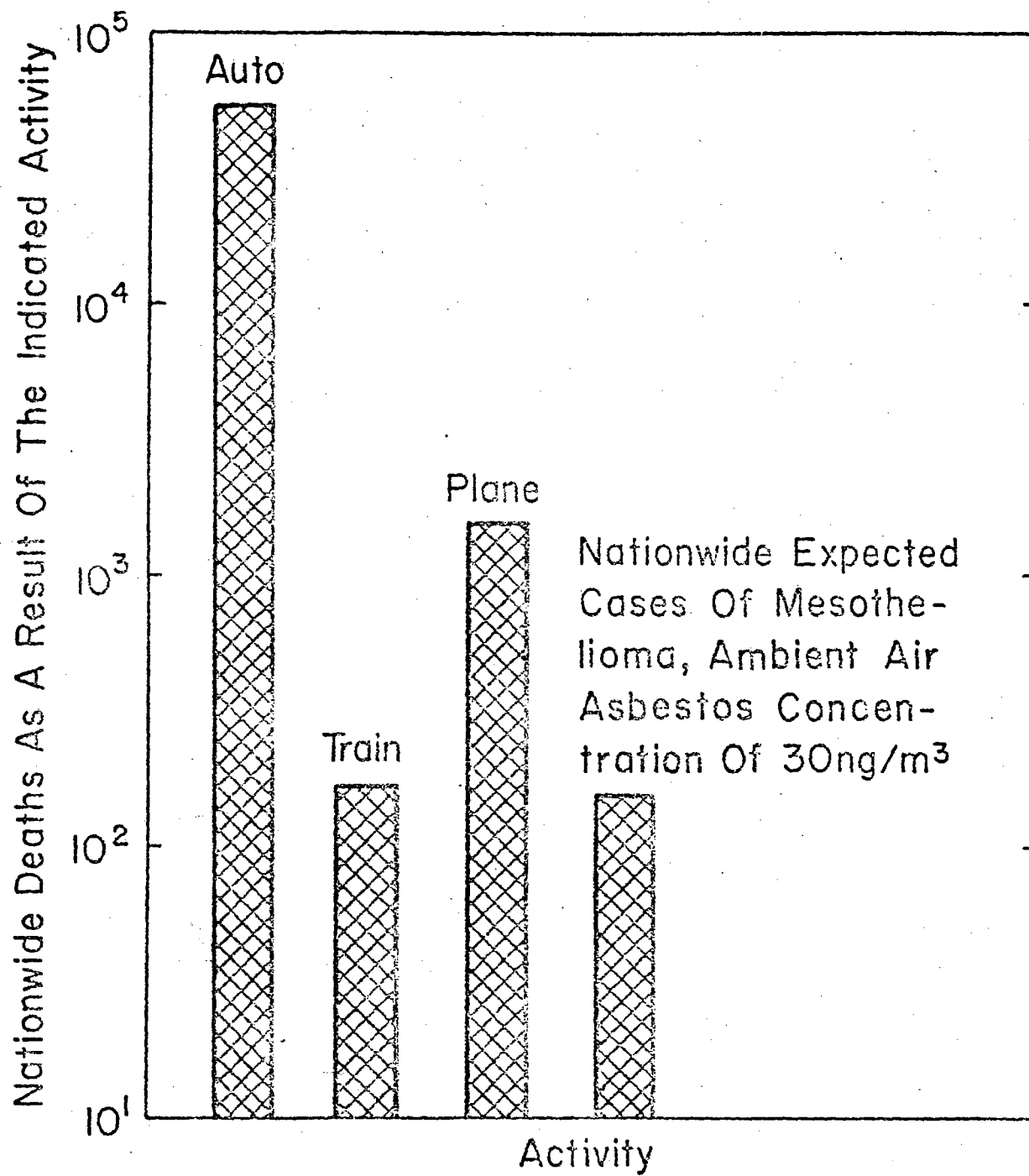
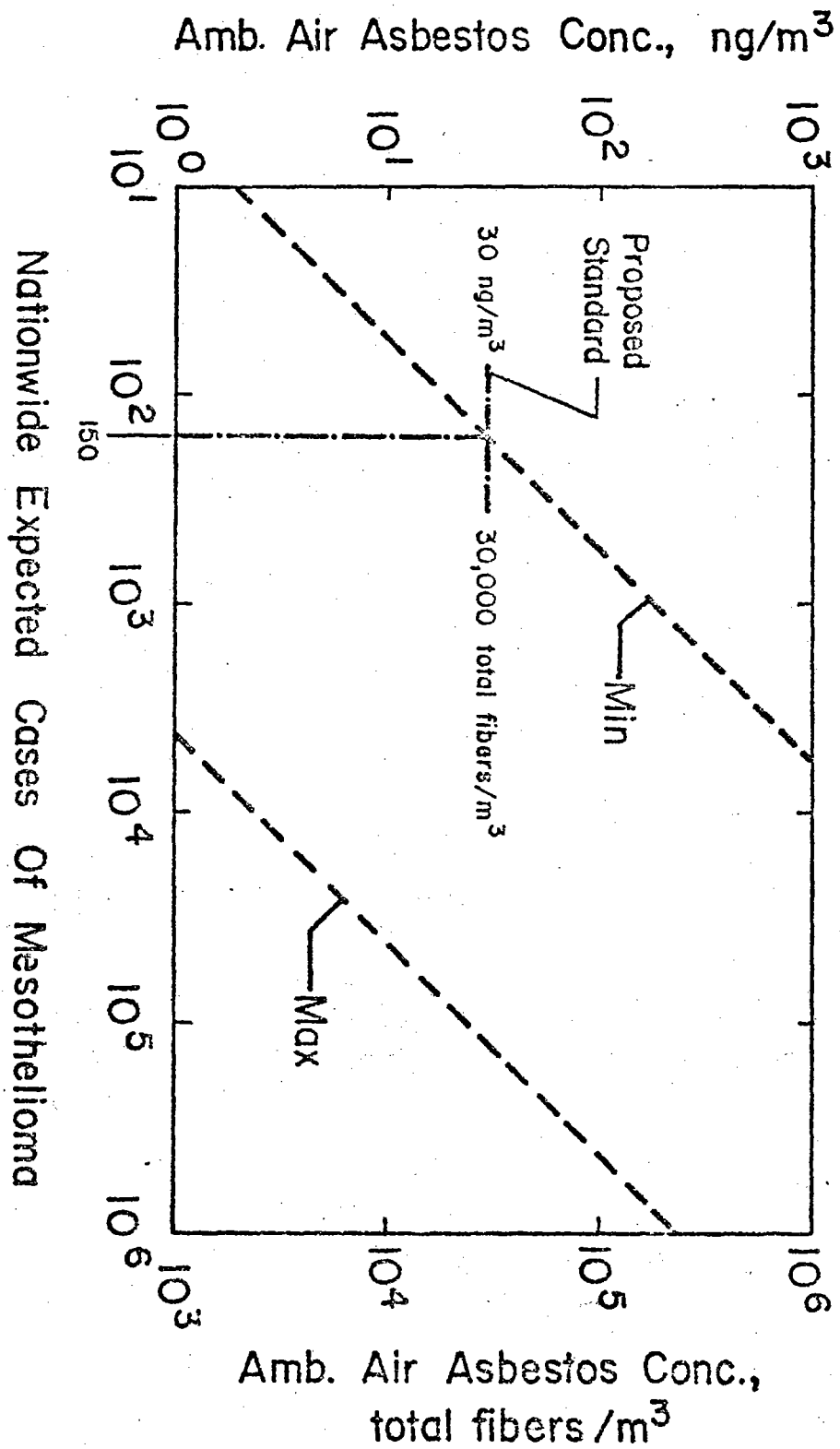


Figure 3. Nationwide Mortality Statistics Due
to Different Modes of Travel and Expected Cases
of Mesothelioma



monitoring standpoint and is not sensitive to short-term perturbations in air asbestos emissions, but at the same time provides the public with a high degree of protection from the adverse health effects caused by excessive asbestos fiber concentrations. Compliance with the proposed standard can be easily and accurately evaluated using Connecticut's low-volume particulate sampler (10-vol).^{6,24}

In certain instances it may be necessary to impose asbestos emission standards on manufacturing and other sources of airborne asbestos fibers in order to attain the desired ambient air asbestos standard. A mass emission standard of 24 g/day (for an isolated point source of asbestos emissions) is consistent with the 30 ng/m³ (30,000 fibers/m³) proposed standard. The development of this emission standard, in addition to a possible stack sampling train, are explained elsewhere.^{3,4}

MESOTHELIOMA INCIDENCE IN CONNECTICUT

The mesothelioma incidence trend in Connecticut men mounted through the 10 year period covering 1960 to 1969 from an age-adjusted rate (AAR), obtained using the indirect method, of 0.04/100,000 Connecticut population for the interval between 1940 and 1949 to 0.37/100,000 from 1960 to 1969. No mesotheliomas were diagnosed in Connecticut women until the period 1950 to 1959 when 12 were reported yielding an AAR of 0.1/100,000. The trend for females increased slightly to 0.15 in 1960 to 1969 (Figure 4). The combined sex AAR rose from 0.02/100,000 during 1940 to 0.25/100,000 from 1960 to 1969, over a 10-fold increase. The increase in cases over the years may in part reflect an increased awareness of this type of tumor and an attempt by pathologists to classify all malignancies. Though increases in both occupational and non-occupational asbestos fiber exposure are expected to have occurred over the last 40 years, only 4 people were reported with known exposure to asbestos. Eight other were felt to have experienced some exposure. Occupation at the time of diagnosis was obtained from hospital admission records and the usual occupation from death certificates. It was found that 44 individuals (33.0%) worked in the home or in like occupations. Thirty-six (27.1%) were reported to have worked in manufacturing industries. Nineteen (14.3%) worked in offices as professionals or clerical employees. Of the remaining individuals it is interesting to note that one person was listed as a toll collector. Unfortunately, complete occupational histories of each of those individuals afflicted with mesothelioma are not available at this time.⁵

Cumulative United States asbestos consumption has increased rapidly since the beginning of the 20th century and is projected to exceed 60 million tons by 1980;²⁵ Connecticut's asbestos consumption has been estimated by proportionally allocating total U.S. consumption using the appropriate Connecticut to United States population ratio. A plot of both cumulative U.S. and Connecticut (estimated) asbestos consumption and Connecticut's combined-sex mesothelioma AAR/100,000 population as a function of time suggests that the sharp increase in mesothelioma incidence closely followed the rapid rise in the State's cumulative asbestos consumption for comparable intervals (i.e., 1940 to 1970) (Figure 5). This apparent cause-effect relationship warrants further investigation.

Figure 4. Connecticut Mesothelioma Incidence
by 10-Year Period

Age-Adjusted Mesothelioma Incidence Rate
Per 100,000 Connecticut Population

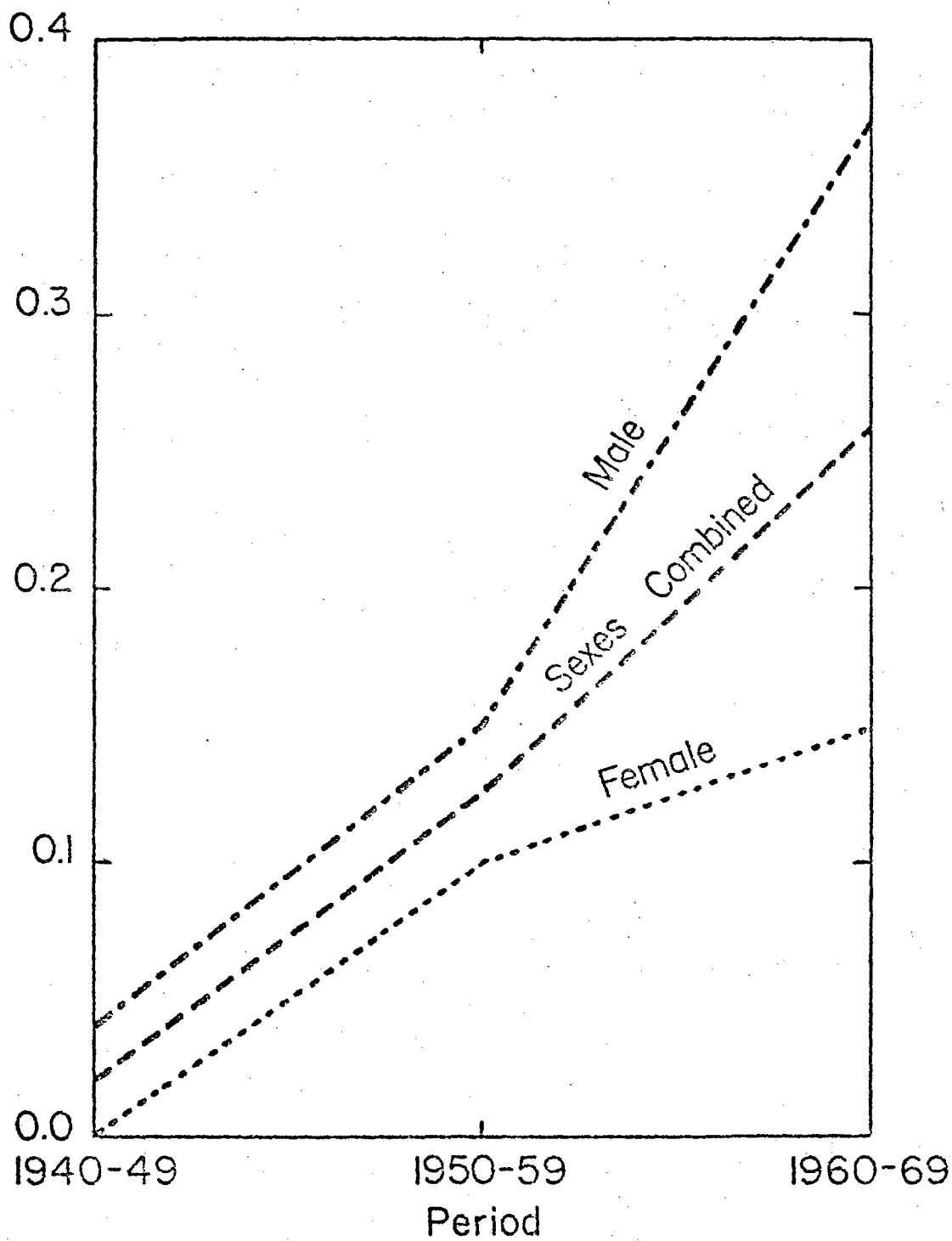
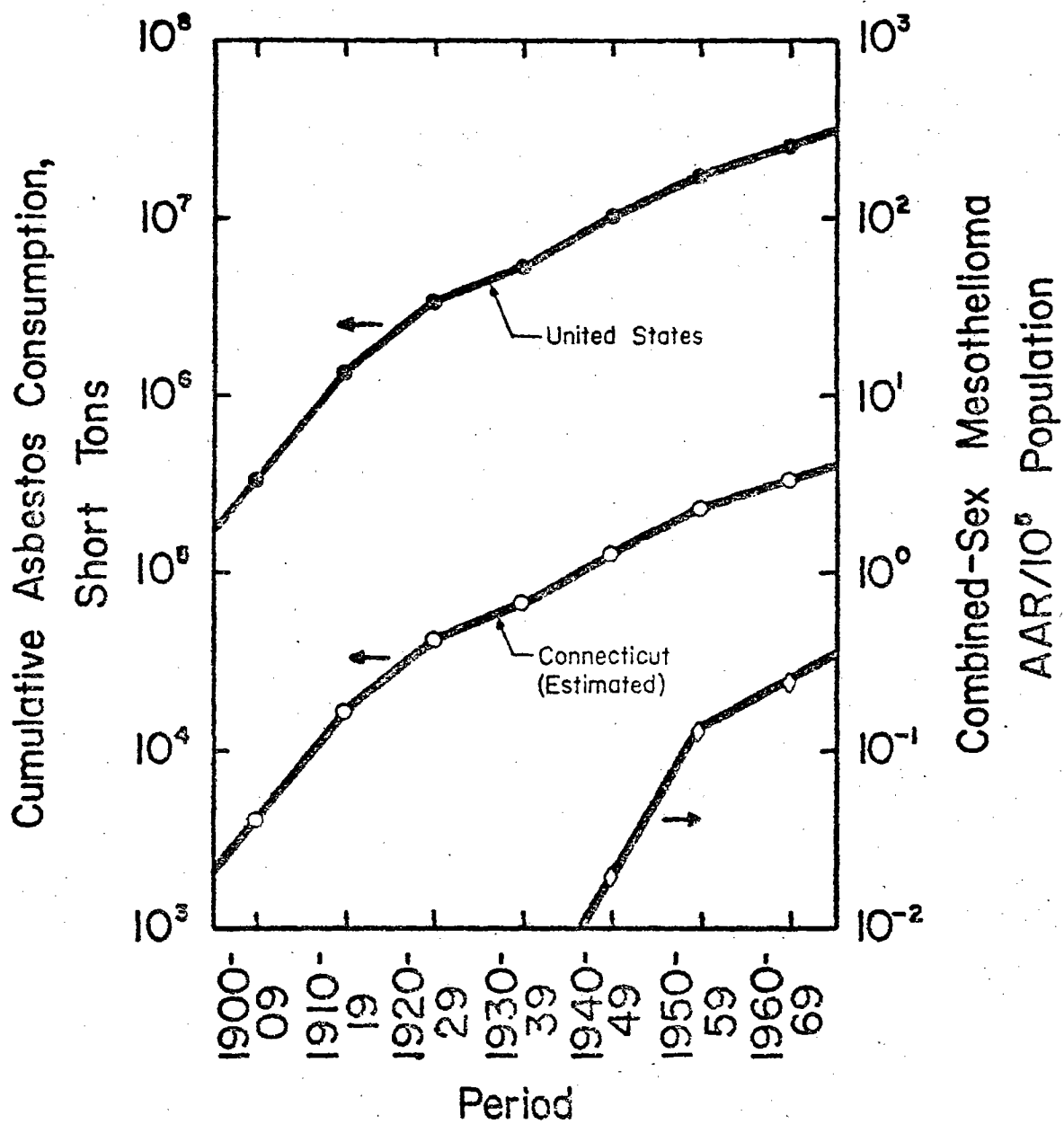


Figure 5. Cumulative Asbestos Consumption and
Connecticut Mesothelioma Incidence as a Function of Time



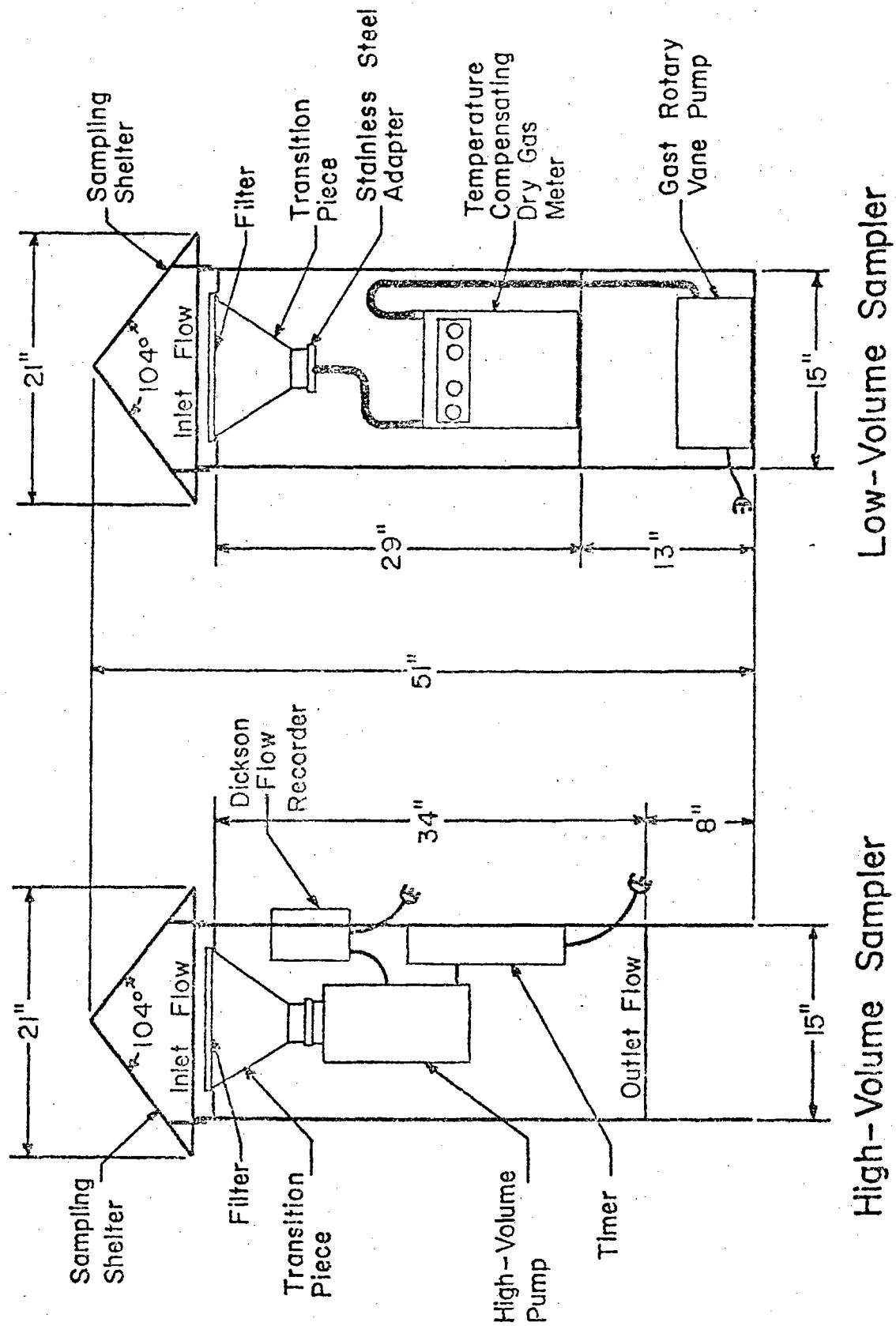
AIR ASBESTOS SURVEY

An ambient air asbestos survey was conducted during late 1975 and early 1976 to define the magnitude of the health hazard posed by airborne asbestos fibers in Connecticut prior to the promulgation of the State's asbestos standard. The newly developed low volume particulate sampler (lo-vol) (see Figure 6); which operates continuously for a 30-day interval at an air sampling flow rate of approximately 4 cfm, was used to collect ambient TSP samples. The lo-vol was equipped with special membrane filters (8" x 10", Gelman Metricel GN-6, 0.45 μ pore size, non-nylon reinforced). The filters were analyzed for chrysotile asbestos by the Batelle-Columbus Laboratories using transmission electron microscopy in conjunction with electron diffraction to confirm a minimum of 10 chrysotile asbestos fibers.⁶

Approximately 30 monitoring sites were selected; locations included "typical" urban sites removed from known sources of asbestos emissions, rural-background sites and station contiguous to 4 industrial users of asbestos (i.e. manufacturers of friction products, insulated wire and cable, ammunition and molding compounds) and 3 toll plazas situated at various locations along Interstate 95. Ambient chrysotile asbestos levels removed from asbestos emission sources in both urban and rural location were below 10 ng/m³. However, chrysotile asbestos concentrations above the 30 ng/m³ proposed standard were measured near each of the industrial users of asbestos (i.e., 32 ng/m³ at a public works building located near the friction products manufacturer; 33 ng/m³ at a junior high school located adjacent to the insulated wire and cable and ammunition manufacturer combination; 33 ng/m³ at a private home near the molding compounds manufacturer). Each of the subject point sources are in compliance with NESHAPS and other existing state and federal air quality regulations.

Ambient asbestos levels adjacent to the 3 toll plazas on I-95 were also elevated (in the 10 ng/m³ to 25 ng/m³ range), implicating asbestos emissions from vehicle brake lining decomposition as a significant source of airborne asbestos fibers. Asbestos concentrations at the rural toll plaza (11,000 cars/day eastbound lane; 12,000 cars/day westbound lane) were 10 μ g/m³ (eastbound lane) and 14 μ g/m³ (westbound lane); there are no known industrial users of asbestos near this rural toll station. Asbestos levels at one of the urban toll plazas (28,000 cars/day eastbound lane; 27,500 cars/day westbound lane) were 3 ng/m³ (Administration Building, south side of highway) and 25 ng/m³ (westbound lane). The asbestos concentration at the other urban toll plaza (27,000 cars/day eastbound lane; 28,000 cars/day westbound lane), which is also located near one of the largest industrial users of asbestos in Connecticut (i.e., the aforementioned friction products manufacturer), was 41 ng/m³ (Administration Building, south side of highway); this was the highest concentration measured during the subject survey. The ratio of the maximum asbestos concentration measured at the first urban toll plaza to that at the rural toll station was approximately equal to the ratio of the number of cars/day passing through each toll plaza (i.e., 1.8 versus

Figure 6. High Volume (Hi-Vol) and Low Volume
(Lo-Vol) TSP Samplers



2.3) during the sampling interval. All of the aforementioned measured asbestos levels were 30-day average values, except the 41 ng/m³ concentration, which was approximately a 20-day average value (due to a sampler malfunction).

In addition to the ambient air asbestos survey described above, asbestos levels were also measured indoors at the boy's swimming pool located in the University of Connecticut's field house. The ceiling covering this pool was sprayed with an asbestos-containing insulating compound in 1948 and then re-sprayed some 10 to 20 years later. Chunks of this coating have been falling from this exposed ceiling for some 2 years. Analyses of a bulk sample of the ceiling material by the Connecticut State Department of Health revealed definite evidence of asbestos fibers (between 10-30%) within fiberglass and binding material. Subsequent electron microscopic analyses of the ceiling material by the Battelle-Columbus Laboratories indicated that the asbestos was of the amphibole variety. Four (4) long-term (i.e., 30-day) air samples were collected at various locations at the pool. Identical sampling techniques were used for both the indoor and outdoor air asbestos surveys. These indoor samples are being analyzed for amphibole asbestos using transmission electron microscopy and energy dispersive electron-diffraction by Walter C. McCrone Associates, Inc. The results of this indoor asbestos survey will be reported at a later date.²⁶

CONCLUSIONS AND RECOMMENDATIONS

Connecticut's studies to-date indicate the existence of a potential health hazard posed by airborne asbestos fibers which warrants further investigation. Firstly, additional ambient asbestos monitoring should be performed as soon as possible to:

- 1) define the month-to-month variations in ambient asbestos levels at various locations, primarily in densely populated areas contiguous to manufacturing sources of asbestos emissions and especially those locations which already exhibited asbestos concentrations in excess of Connecticut's standard,
- 2) further quantify, asbestos levels near toll stations, the relationship between traffic counts and ambient asbestos concentrations, and determine how asbestos levels decline with increasing distance from a toll plaza,
- 3) define ambient asbestos concentrations contiguous to different types of demolition operations and how rapidly these levels approach background concentrations after the demolition activity is completed,
- 4) quantify the hazard posed by asbestos concentration indoors where it is suspected that asbestos-containing spray-on materials are fraying and flaking.

Secondly, the relationship between asbestos consumption and mesothelioma incidence in Connecticut should be investigated in more detail. A thorough epidemiological study of the 133 reported cases of mesothelioma (as of 1972) should be performed as soon as possible to identify those cases which are likely associated with non-occupational asbestos fiber exposure. A prospective study of school children exposed to asbestos fibers indoors as a result of the spray-on application and deterioration of asbestos-containing surface coatings should be conducted to accurately quantify the health hazard posed by this type of asbestos fiber exposure.

It is recommended that Connecticut's standard be promulgated and applied both outdoors and indoors. The routine monitoring of asbestos levels should be initiated as soon as possible. The resulting measured concentrations (along with the populations exposed) should be compared to the standard so that a rational program and set of priorities can be formulated to minimize the health hazard posed by airborne asbestos fibers. This seems to be the most logical way to objectively determine how best to allocate the people's money in implementing sensible ways of controlling contamination of the environment by airborne asbestos fibers.

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