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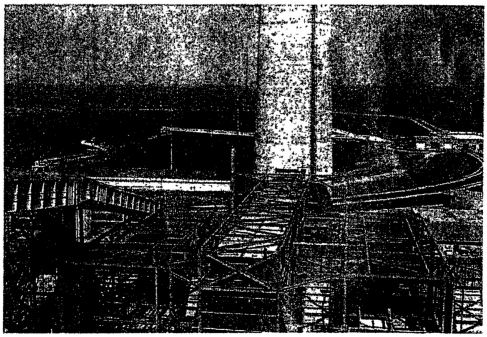

Monitored Asbestos Concentrations in Connecticut

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An air asbestos survey was conducted between late 1974 and early 1977 to define the magnitude of the health hazard posed by airborne asbestos fibers in Connecticut prior to the promulgation of the State's proposed asbestos air quality standard (i.e., 30 ηg/m³ or 30,000 total asbestos fibers/m³, 30-day average). A newly developed low volume particulate sampler, which operates continuously for 30 days at an air sampling flow rate of 4 cfm, equipped with special membrane filters was used to collect ambient TSP samples for subsequent chrysotile asbestos electron microscopic determination by the Battelle-Columbus Laboratories and Walter C. McCrone Associates.

Approximately 40 monitoring sites were selected; ambient locations included "typical" urban sites removed from known stationary sources of asbestos emissions, rural-background sites, stations contiguous to 4 industrial users of asbestos (i.e., manufacturers of friction products, insulated wire and cable, ammunition and molding compounds), 3 toll plazas situated at various points along Interstate 95 and indoors at a swimming pool at the University of Connecticut (the ceiling over the pool was sprayed with an asbestos-containing insulating material). Ambient chrysotile asbestos levels removed from asbestos emission sources in both urban and rural locations were below 10 ηg/m³. However, asbestos concentrations above 30 ηg/m³ were measured near each of the industrial users of asbestos. Furthermore, asbestos levels adjacent to the toll plazas were also elevated (in the 10 ηg/m³ to 25 ηg/m³ range), implicating asbestos emissions from vehicle braking lining decomposition as a significant source of airborne asbestos fibers. Indoor air asbestos levels were below 1 ηg/m³ suggesting that the risk to public health associated with the deterioration of asbestos surface coatings applied indoors may not be as severe as previously thought.

Asbestos, the general term used to describe a class of fibrous silicate minerals, is widely used in industry and construction. The principal variety of asbestos used in industry is the serpentine form known as chrysotile (greater than 95%) with the amphibole forms of asbestos being of lesser significance. Occupational asbestos fiber exposure has been known for some time to cause severe respiratory problems, including lung cancer and a relatively rare form of cancer of the lining of the lung and stomach, known as "mesothelioma." Recently, the previously rare mesothelial malignancy has been linked to nonoccupational asbestos fiber exposure [1-9]

In 1973 the U. S. EPA, recognizing the need to control the emissions of asbestos fibers into the ambient air, promulgated National Emission Standards for Hazardous Air Pollutants (*asbestos*, beryllium, and mercury).[10] After an extensive review, the Connecticut DEP found EPA's asbestos regulation to be inadequate for the purposes of protecting public health in Connecticut and, consequently, developed its own asbestos regulation.[11,12] While EPA's asbestos regulation was written in rather general terms (i.e., "no visible emissions or application of best available control technology"), Connecticut proposed a numerical ambient air quality standard of 30 ηg/m³ or 30,000 total asbestos fibers per cubic meter of air sampled, 30-day average, and a compatible mass emission standard of 24 g/day. In the judgment of the Connecticut DEP 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 proposed to control more stringently the demolition of asbestos-containing structures.

In order to define the magnitude of the hazard posed by airborne asbestos fibers in Connecticut prior to the promulgation of the state's proposed standard the DEP conducted an ambient air asbestos survey along with a study of asbestos-induced mesothelioma incidence in Connecticut. The results of the health study indicated that Connecticut's mesothelioma incidence rate has exhibited a 10-fold increase since 1940. This rapid rise in the state's mesothelioma incidence rate closely parallels Connecticut's rate of increase in cumulative asbestos consumption. Approximately 90% of these mesothelioma cases did not have a trade where exposure to asbestos was a common feature. The results of this study are described elsewhere.[13] An ambient air asbestos survey was conducted during 1975 at approximately 30 monitoring sites; locations included rural, semi-rural locales, urban areas, and stations situated contiguous to known sources of asbestos emissions (e.g., industrial users of asbestos and toll plazas). In addition, an indoor air asbestos survey was conducted in 1977 at a swimming pool located in the University of Connecticut's Field House; the ceiling covering this pool was

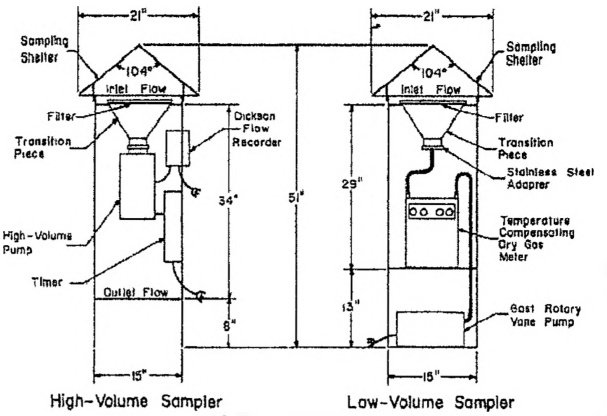

Figure 1. High volume (Hi-vol) and low volume (Lo-vol) ambient TSP samplers.

sprayed with an asbestos-containing insulating compound and chunks of this surface coating have been falling from this ceiling for some time. A newly developed low volume particulate sampler was used to collect samples for subsequent chrysotile asbestos determination. The following discussion presents the results of Connecticut's air asbestos surveys.

Sources of Airborne Asbestos Fibers in Connecticut

Outdoors, the manufacture of products which contain asbestos, such as asbestos cement, floor tile, paper, friction materials, and textiles, are the major sources of ambient airborne asbestos fibers in Connecticut, accounting for approximately 10 tons of asbestos emissions each year.[12,13] Another potentially significant source of airborne asbestos fibers is the erosion of vehicle brake linings and clutch facings and the subsequent release of asbestos. Asbestos is used in vehicle brake linings to provide strength, heat resistance, and selective decomposition under stress. Chrysotile asbestos constitutes approximately 50% (by weight) of most vehicle brake linings manufactured in the U. S.[14] During braking the application of energy is so intense and the heat created so great that most of the asbestos fibers are converted to other nonfibrous substances, however, a significant percentage remain in the asbestos form. Consequently, it is possible that ambient asbestos levels contiguous to areas of extensive vehicle braking, such as toll plazas, may be significantly higher than background locations. In Connecticut, the erosion of vehicle brake linings and clutch facings is estimated to contribute an additional 2 tons of asbestos fibers into the ambient air annually.[12] Perhaps the largest potential future source of asbestos emissions in Connecticut will be the demolition of structures containing asbestos floor and ceiling tiles and which have been insulated and/or fireproofed with asbestos materials.[13]

The health risk posed to the general population by asbestos fibers is not limited to either the indoor occupational environment or the outdoor ambient air. 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 . . ., the cutting and sawing of asbestos-containing wallboard, ceiling, and floor tile and the sanding of spackling compounds containing asbestos. 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 (thermal and acoustic), decorating, and fireproofing purposes. As a result of such applications 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, are of primary public health concern. At least one state (i.e., New Jersey) and a local municipality (i.e., New Haven, CT) have already drafted regulations for the purposes of controlling and/or prohibiting the future use of spray-on asbestos surface coatings indoors. NESHAPS prohibits the use of such asbestos-containing spray-on insulation and fireproofing materials outdoors;[10] a recent amendment to NESHAPS proposes to prohibit the future use of any type of spray-on asbestos coatings indoors.[15]

Sampling Methodology

Connecticut's proposed asbestos ambient air quality standard is based on a 30-day average sampling period instead of the usual 24 hr duration because a one-month averaging time is more manageable from a monitoring standpoint, is also not sensitive to short-term perturbations in asbestos emissions, yet still provides the public with a high degree of protection from the adverse health effects caused by excessive asbestos fiber exposure. In order to determine compliance with such a standard a new type of low volume ambient particulate sampler, which operates continuously for 30 days, was developed.[16,17]

This low volume particulate sampler (lo-vol) was designed around the constraints that it must use an air sampling flow rate low enough to prevent filter overloading and subsequent biasing of the sample toward the beginning of the 30 day sampling interval. The lo-vol produced measurement is essentially an arithmetic average for the entire 30-day sampling period.

The lo-vol is essentially a combination of parts taken from a conventional hi-vol sampler and a stack sampling train (see Figure 1). The lo-vol consists of a modified hi-vol shelter, filter holder, transition piece, a temperature compensating dry gas meter and a vacuum pump. The hi-vol transition piece is used as the lo-vol's filter holder. The transition piece has been fitted with a specially designed stainless steel adapter plate and is

connected to a dry gas meter with thick-walled (i.e., 0.5 in. inside diameter, 0.75 in. outside diameter) tygon tubing. The dry gas meter is an American Meter #AL250, which is temperature compensating at 60°F and rated at 250 cubic feet per hour (cfh). The meter has been fitted with standard gas pipe connections sized to fit the tygon tubing. This meter provides an air sampling flow rate measurement accuracy of ± 0.01 cfm. The power for the lo-vol is supplied by an oilless Gast Rotary Vane Pump Model #0522, which delivers 200 cfh at a pressure of 5 in. of mercury. The lo-vol operates at an air sampling flow rate of 4 cfm or 1/10 of that used by a conventional hi-vol sampler. Therefore, a lo-vol filter collects approximately 2 to 3 times as much sample, by weight, as compared to that amount collected by a standard 24-hr hi-vol. Thus, the lo-vol should provide a more accurate chemical characterization of the TSP, especially for those substances which are usually present in very low concentrations, such as asbestos.

Table 1. Summary of air asbestos survey.

Site classification	Sampling period	Number of samples	Range of measured chrysotile asbestos concentrations, 30-day average, ng/m³ High	Low
Source Oriented; Manufacturer of Friction Products	10/17/75–11/14/75	5	32	2
Source Oriented; Manufacturer of Ammunition and Manufacturer of Insulated Wire & Cable	10/17/75–11/14/75	4	33	3
Source Oriented; Manufacturer of Molding Compounds	1/26/76–2/27/76	4	33	3
Source Oriented; Toll Plazas on Interstate 95	10/17/75–11/14/75	5	41[a]	3
Source Oriented; Indoors, Boy's Swimming Pool at University of Connecticut (Asbestos Sprayed Ceiling)	3/11/77–4/11/77	4	<1	<1
Non-Source Oriented; Urban	11/7/74–12/10/74; 10/17/75–11/14/75; 1/26/76–2/27/76	9	9	<1
Non-Source Oriented; Rural	11/7/74–12/10/74; 10/17/75–11/14/75; 1/26/76–2/27/76	7	6	<1

[a] 20-day average

As a quality control check of the performance of the lo-vol the Connecticut Department of Environmental Protection co-located a lo-vol and a hi-vol on the roof of the State Office Building in Hartford. Continuous TSP data were collected for a 1-yr period. Monthly mean TSP concentrations obtained using the lo-vol were, on the average, 7% greater than the arithmetic mean of 30 consecutive nonoverlapping daily hi-vol measurements for the twelve 30-day intervals. A detailed description of this test program is reported elsewhere.[16,17]

Membrane collection filters (8 in. × 10 in., Gelman* Metrical GN-6, 0.45μ pore size, non-nylon reinforced) were used since the glass fibers in conventional fiber glass filters interfere with the analytical technique used to ascertain the asbestos content of air samples. Serpentine (i.e., chrysotile) asbestos analysis of the ambient samples was performed by the Battelle-Columbus Laboratories using electron microscopy;[18] the accuracy of the method used to determine the asbestos content of the air samples was estimated to be ±50%, based on the analysis of activated chrysotile asbestos samples.[19] Analytical results are expressed in terms of mass of chrysotile asbestos per cubic meter of air sampled. Serpentine and amphibole asbestos analyses of the indoor samples were conducted by Walter C. McCrone Associates using electron microscopy in combination with energy dispersive electron diffraction.

Sampling Locations

Approximately 30 monitoring sites were selected for the ambient survey (see Table I and Figure 2); locations included "typical" urban and rural background areas and stations contiguous to 4 manufacturing sources of asbestos emissions (i.e., a manufacturer of friction products, a manufacturer of insulating wire and cable, a manufacturer of ammunition, and a manufacturer of molding compounds) and 3 toll plazas situated at various points along the Connecticut Turnpike (I-95).

Source #1 uses approximately 600 tons/month of asbestos in the manufacture of asbestos-containing friction and gaskets materials. This source has over 1000 point ventilation streams at mixing (i.e., raw materials including asbestos and other inert materials are compounded on various types of mixing devices), forming (i.e., compounds are formed into pads and various friction and gasket products) grinding, and machining operations. These streams are combined into 20 final streams, each exhausting to the atmosphere through an air mover and a control device (i.e., 10 baghouses and 10 wet cyclone-venturi scrubber combinations; estimated asbestos control efficiency 98–99%+).

Source #2 uses approximately 3–6 tons/month of asbestos in the manufacture of insulated wire and cable. Asbestos is applied to wire and cable using carding, taping and braiding machines. The carding machines vent to baghouses, each collecting exhausts from 2 machines. There are 3 sizes of braiders at this plant, sized according to the number of spindles in the braids. The small braider exhausts to a baghouse, then vents to the outside. The medium and large braiders are exhausted to a separate piece of control equipment and are vented inside the plant. The taping machine is controlled by a cyclone-baghouse combination and also vents inside. All control equipment used here are estimated to be 99+% efficient in removing asbestos from waste streams.

Source #3, which is located about ½ mile from source #2, uses approximately 40 tons/month of asbestos in the manufacture of ammunition. Here, chrysotile asbestos is blended with wood flour and paraffin wax. This blended material is then mixed in a steam-heated ribbon blender and stored in a silo for feeding into a Colton Tablet machine where the "wads" are formed into their final shape. The blending operation is vented to a wet cyclone which has an estimated asbestos control efficiency of approximately 95%.

Source #4 uses approximately 150 tons/month of asbestos in the manufacture of molding compounds. One process involves the mixing of dry powdered phenolic resins with glass, asbestos, and other additives. This mixture is then transferred to a shaping line where the dry resin mixture with added

* Mention of either commercial products or company names does not constitute an endorsement by the Connecticut Department of Environmental Protection.

plasticizer is milled and compounded to a desired thickness. Then, the sheet is preground and carried by a vacuum line back to the area where it was originally mixed. There it is processed by sizing screens to a desired mesh size. Then a large batch is blended to maintain consistency and packaged for sale. Another process combines formaldehyde-phenol liquid resins with dry resins and various grades of asbestos. This mixture is kneaded, extruded, dried, and sized. Large amounts are blended and packaged. The last process involves blending pulp, dry resins, asbestos and fillers and then forming a sheet on a cylinder paper machine. Asbestos is added to the beater just before the pulp is dumped to the stock chest. The sheet can be of varying thickness up to $\frac{3}{8}$ in. It is oven dried after forming, then sized to sheets 4 ft × 5 ft and sold. In the first process the mixing tank, sizing screens and blender are exhausted to a baghouse. The sizing line has exhausts from the fluxing mill and the pregrinder which is also collected in a baghouse. The 3 extrusion lines have sizers and driers exhausting to 3 separate baghouses. The 2 beaters where asbestos is added are hooded and also exhaust to a baghouse, which collects dust from the 3 loading chutes and kneaders used in the extrusion lines. All the baghouses are rated at a 99%+ asbestos removal efficiency.

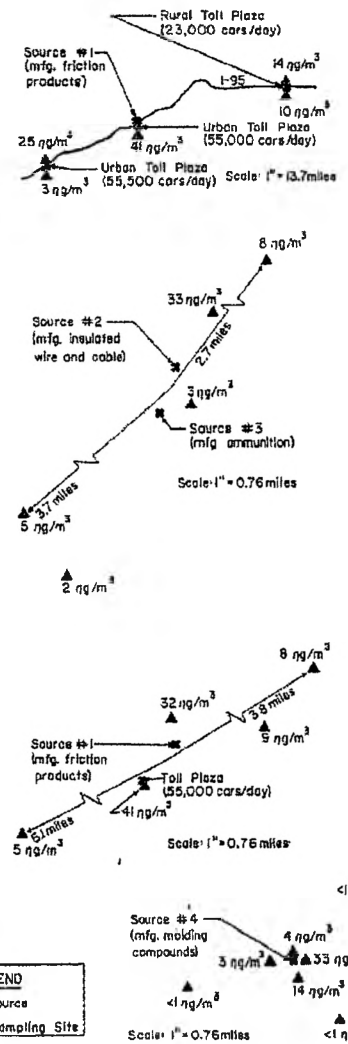

Figure 2. Ambient asbestos levels near several different industrial users of asbestos.

Four sites were chosen for the indoor survey; two samplers were located on each side of the swimming pool on the middle bleacher level at a distance of approximately 15 ft from each end of the pool (See Figure 3). The ceiling covering this pool was sprayed with a mixture of asbestos, fibrous glass, and cementitious binder which formed an exposed nonhomogeneous coating several inches in thickness with sound and fire retardant properties. The exposed and friable ceiling showed some visible evidence of deterioration. Furthermore, there were visible (to the naked eye) pieces of ceiling material on the bleachers located in the uppermost level of the pool area (see Figures 4 and 5).[20]

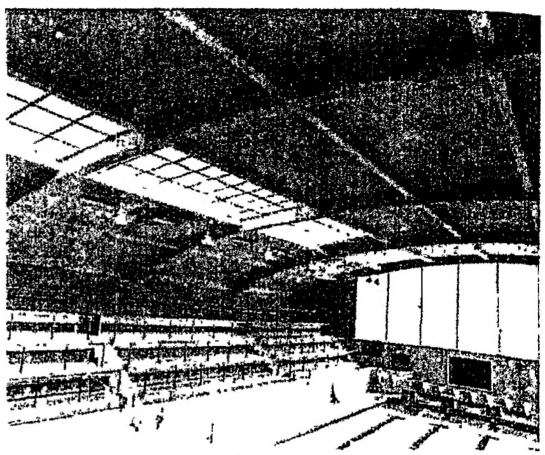

Figure 3. Swimming pool area: hi-vol samplers were located on middle weather level, at a distance of 15 ft from each end of pool.

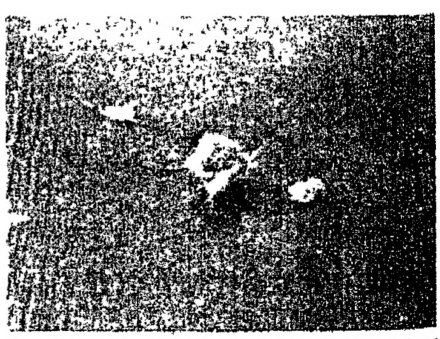

Figure 4. Chunk of ceiling coating material on upper level bleachers.

Results and Discussion

Ambient chrysotile asbestos concentrations removed from significant point sources of asbestos emissions in both rural and urban locations were below 10 ng/m³ (See Table I). For the 7 rural sites asbestos levels ranged from <1 ng/m³ to 6 ng/m³. For the 9 urban sites removed from known sources,

asbestos concentrations varied from <1 $\eta g/m^3$ (almost half of the urban sites) to 9 $\eta g/m^3$. However, asbestos levels at the monitoring sites located contiguous to certain industrial users of asbestos in Connecticut were elevated with at least one site near each source exceeding the state's proposed 30 $\eta g/m^3$ asbestos air quality standard (i.e., 32 $\eta g/m^3$ at a Public Works building located near the friction products manufacturer; 33 $\eta g/m^3$ at a Junior High School located adjacent to the insulated cable and wire and ammunition manufacturer combination; 33 $\eta g/m^3$ at a private home near the molding compounds manufacturer—see Figure 2). It is noteworthy that each of the subject point sources is 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 $\eta g/m^3$ to 25 $\eta g/m^3$ range), implicating asbestos emissions from vehicle brake lining decomposition as a significant source of airborne asbestos fibers (see Figure 2). Asbestos concentrations at the rural toll plaza (11,000 cars/day eastbound lane; 12,000 cars/day westbound lane) were 10 $\eta g/m^3$ (eastbound lane) and 14 $\eta g/m^3$ (westbound lane); there are no known industrial users of asbestos near this toll station. Asbestos levels at one of the urban toll

Figure 5. Close-up of ceiling depicting badly deteriorated condition of coating material. This portion of ceiling is readily accessible.

plazas (28,000 cars/day eastbound lane; 27,500 cars/day westbound lane) were 3 $\eta g/m^3$ (Administration Building, south side of highway) and 25 $\eta g/m^3$ (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, was 41 $\eta g/m^3$ (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 2.3) during the sampling interval. All of the aforementioned measured asbestos levels were 30-day average values, except the 41 $\eta g/m^3$ concentration, which was approximately a 20-day average value (due to a sampler malfunction).

Both the serpentine (i.e., chrysotile) and amphibole (i.e., amosite) asbestos content of the four indoor samples were below 1 $\eta g/m^3$.

Conclusions and Recommendations

Methods of asbestos analysis should be standardized as soon as possible since laboratories performing asbestos counting use different techniques which can produce varying results. However, findings within laboratories can be reproducible, with results approaching ±50%.

Ambient asbestos levels in both rural and urban areas (removed from industrial users of asbestos) were relatively low (i.e., less than 10 $\eta g/m^3$) indicating that the "ambient asbestos problem" is limited to populations residing in close proximity to point sources of asbestos emissions. Ambient asbestos concentrations adjacent to several different industrial users of asbestos exceeded Connecticut's proposed asbestos air quality standard of 30 $\eta g/m^3$, 30-day average (i.e., 32 $\eta g/m^3$—manufacturer of insulated wire and cable and manufacturer of ammunition, located approximately ½ mile apart; 33 $\eta g/m^3$—manufacturer of molding compounds, 32 $\eta g/m^3$—manufacturer of friction products) in spite of the fact that each source was in compliance with NESHAPS and other current applicable state and federal air quality regulations. Additional monitoring should be conducted to define month-to-month variations in ambient asbestos levels near these subject industrial users of asbestos, as well as other sources of asbestos emissions. Ambient asbestos levels at 3 toll plazas situated at various locations along I-95 were all relatively elevated (i.e., concentrations varied between 10 $\eta g/m^3$ and 25 $\eta g/m^3$) implicating vehicle brake lining decomposition as a significant source of airborne asbestos fibers. The highest measured asbestos concentration (i.e., 41 $\eta g/m^3$) for the entire survey was recorded at the monitoring site located adjacent to an urban toll station and one of the largest industrial users of asbestos in the state. Additional monitoring should be conducted near other toll plazas to define better the relationship between the number of vehicles/day passing through a toll station and ambient asbestos levels; data collected during the subject survey suggest a linear relationship. The quantity of asbestos fiber dust released during the demolition of structures containing asbestos floor and ceiling tile and/or which have been insulated or fireproofed with asbestos materials should be quantified as soon as possible.

The indoor survey, though limited in nature, suggests that the risk to public health posed by the application of asbestos-containing surface coatings to the inside structural framework of schools and other public buildings and the subsequent release of asbestos fibers as the coating deteriorates with time, may not be as great as previously thought; indoor asbestos levels were below 1 $\eta g/m^3$. It is strongly recommended that airborne asbestos fiber concentrations be determined (using electron microscopy) and compared to the 30 $\eta g/m^3$ (or 30,000 fibers/m^3) standard before any extensive corrective action is taken regarding the removal of asbestos-containing coating materials. Current asbestos analysis techniques are relatively expensive (costs may range anywhere from $250–$1000/sample); however, the cost of embarking on a program to correct a problem that poses little apparent public health risk is much more expensive in the long run. While it may be prudent to minimize any exposure to a carcinogenic substance (such as asbestos) the societal costs of removing all environmental carcinogens would be prohibitive. The problem of how effectively to reduce environmental exposure to toxic substances must be addressed in a rational, objective manner. A realistic assessment of public health risk based on 1) relative pollutant toxicity, 2) relative environmental exposure potential from various media, and 3) populations-at-risk must be made. This seems to be the most logical way to determine how best to allocate the people's money in implementing sensible ways of controlling contamination of the environment by airborne asbestos fibers and other toxic substances.

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