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Airborne Concentrations of Asbestos-in-air in Buildings and Exposure of Occupants: Risk and Regulatory Implications

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Abstract

Concern for the health risk of occupants in buildings containing asbestos fireproofing, acoustic materials or lagging, among other products, has led to several investigations of airborne asbestos concentrations in buildings and exposure assessments of occupants and maintenance personnel. The purpose of this paper is to summarize these results, to place in perspective exposure to occupants and maintenance personnel, and to estimate risks based on these exposures. Regulatory implications of these results are discussed. It is concluded that asbestos-in-air measurements carried out with the most appropriate methods in buildings with damaged or undamaged asbestos-containing materials consistently show extremely low concentrations comparable to those measured outdoors for fibers greater than 5 µm in length. Risks to occupants in such buildings are correspondingly very low. Potential exposures are higher to those performing building maintenance procedures that may disturb the asbestos-containing materials. Operations and maintenance procedures are effective in protecting maintenance personnel through engineering controls, work practices and personal protective devices, which are used to a greater or lesser extent depending on the specific activity.

KEY WORDS:
Asbestos, Asbestos-in-air, Occupant exposure, Building exposure.

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Introduction

The genesis of the asbestos-in-buildings issue stems from the Environmental Protection Agency's concern regarding asbestos in schools. This concern was first expressed in a 1979 guidance document issued by the Agency to school administrators (EPA, 1979). From the outset the EPA did not undertake the gathering of data relative to the concentrations of asbestos in the air inhaled by school children in buildings with asbestos materials. Rather, the EPA called for an exercise by school administrators involving an algorithm to determine the course of action to be taken in a particular school building. The algorithm drew on seven observable physical features of the school and involved performance of calculations to arrive at a final number which indicated whether or not action should be taken, namely removal of the asbestos-containing materials (ACM). In the vast majority of cases the result of the exercise was to call for removal. The algorithm was subsequently disproved on the grounds that it did not correlate with any measurements of asbestos-in-air. These events are recounted in detail in a paper presented at Harvard University in 1988 (Corn, 1988). They are also recounted in an editorial by Philip Abelson in Science (Abelson, 1990). The U.S. concern for ACM in schools resulted in promulgation of the Asbestos Hazard Emergency Response Act in 1986. This Act requires that ACM in schools be identified and that action be undertaken to control fiber release. The most common action has been removal. There is U.S. Congress consideration to extend this rule to approximately 750 000 public and commercial buildings.

In this presentation the concentrations of asbestos-in-air in schools and public buildings will be reviewed together with the associated risk estimates. Appropriate regulatory response to these facts will then be considered.

Concentrations of Asbestos-in-Air of Buildings

The most recent publication confirming the low concentrations of asbestos-in-air in buildings is that by Chesson et. al. (1990b). Table 1 is a summary of results from several data sources, presented by Crump (1990). Some of these results were previously presented (Mossman, et al., 1990). The sources of data in Table 1 are a survey conducted by the U.S. Environmental Protection Agency (EPA) of Government Services Administration (GSA) buildings and data from 71 schools involved in impending litigation regarding the presence of ACM products and recovery of the cost of their removal (Corn et. al., 1991). Table 1 contains the average levels from these two data sources. Also included are data from Minnesota state university buildings and Maryland state buildings; these data were generated in connection with impending litigation for recovery of ACM removal costs and were collected and analyzed by the same organizations employing exactly the same protocols as those used in the 71-schools study (Crump, 1990). The same laboratory utilized transmission electron microscopy (TEM) to analyze all the samples used to calculate the results in Table 1. In general, all samples represent approximately 2000 ft^3 of air sampled. The use of TEM with a direct sample preparation methodology aims to determine the concentrations of asbestos fibers in air by measuring fibers as they exist in air. Indirect methods for TEM sample preparation break up structures into their constituent components. The two methods do not yield comparable results.

The data in Table 1 indicate that concentrations in school buildings with ACM average about 0.00024 s/cc (greater than 5 microns in length) per cubic centimeter, and about 0.00007 s/c (greater than 5 microns in length) in non-school buildings with ACM. The 71 schools providing samples were scheduled for abatement and one might argue that airborne asbestos in these buildings presents a "worst case" scenario. The primary feature of Table 1 results is their consistency in indicating low levels of exposure of occupants to asbestos-in-air fibers greater than 5 microns in length, a conclusion also reached by Chesson et al. (1990a). A more extensive treatment of available results of air sampling in buildings is presented in literature review and synthesis of current

Table 1 Average indoor concentrations of airborne asbestos greater than 5 microns in length (Crump, 1990).

Sites	Number of buildings	Number of samples	Structures/cc
GSA buildings			
No ACM*	6	42	0.0
Undamaged ACM*	6	42	0.00007
Damaged ACM*	37	256	0.0008
71 schools	71	328	0.00024
Minnesota universities	34	170	0.00003
Maryland public buildings	72	91	0.00009

* Differences in these concentrations among three groups of buildings are not statistically significant.

knowledge of asbestos in public and commercial buildings published by the Health Effects Institute/Asbestos Research as the work of a blue ribbon review committee (HEI/AR, 1991). Results in this report include a reservoir of unpublished air sampling data which are comparable to the results shown in Table 1. The results indicate that building occupants breathe approximately the same amount of asbestos-in-air (fibers longer than 5 microns) when in the building as when outdoors (Corn et al., 1991). The latter concentration is less than 0.0001 s/cc longer than 5 μm (Corn et al., 1991).

A concern of many building occupants and the EPA is the occurrence of "episodic" releases of fibers from ACM in buildings. These releases are visualized to occur during maintenance or custodial worker intrusion, albeit unintentional, into the ACM. The absence of high concentrations among high volume samples, e.g. 2000 ft^3 analyzed by TEM suggests that such releases, if they occur, while probably resulting in elevated asbestos-in-air concentrations for short durations in the breathing zones of the workmen, are diluted as distance from the source increases and mixing with building air occurs. Table 1 data are based on a total of 1185 samples, each collected over a period of two consecutive days during normal building activities, which cumulatively are equivalent to more than three years of continuous sampling. Thus, if such episodes occur, they either do so infrequently or produce exposures for short durations that are not reflected in the longer-term sampling on which Table 1 averages are based. Crump and Farrar (1989) calculated the probability of such an event occurring and being detected in the GSA building study. They concluded there was a 0.985 probability of detecting such a 10-minute release of 20 s/cc occurring once per year. Despite this high likelihood no episodic releases were detected. In summary, there does not appear to be an increased risk to building occupants (those who do not intrude into ACM) from inhalation of asbestos-in-air.

Risks from Inhalation of Asbestos in Buildings

The linear extrapolation, no threshold, model for estimation of risks of cancer at levels of exposure for which there are no dose/response data has been used to estimate risks to school children from breathing asbestos-in-air at a concentration of 0.001 f/cc greater than 5 microns in length (Hughes and Weill, 1986). The calculated risk was judged to be a very small one, lower than many common risks that children encounter. Mossman, et al. (1990) calculated the risk to school children breathing 0.00024 structures/cc (greater than 5 micron) to be 0.36 per million. The data in Table 1 indicate that asbestos-in-air concentrations in non-school buildings average 0.00007 s/cc (greater than 5 microns). Using the same methods of linear, no threshold extrapolation of dose/response data from epidemiological studies of occupational cohorts, the expected number of premature deaths per million for those workers breathing air with asbestos at this concentration for 20 years is 0.43, or less than 1 per million, a level of environmental risk judged to be insignificant compared to other commonplace risks in life. It is also below the risk level of 10^{-6} judged by EPA to be a Minimum Individual Risk (MIR) (EPA, 1990).

Approach to ACM in Buildings

Because intrusion into the matrix can release fibers, those at potential risk are maintenance and custodial personnel. Those closest to a source of emission of a toxic agent are always at highest potential risk. However, the matter is further complicated by the enormous diversity of building construction and the necessity to analyze in any given building the maintenance and custodial tasks that have high probability of intrusion into the

ACM matrix. So-called Operations and Maintenance Plans (OMP) must be hand-tailored to the individual building. Many consultants in this field are distributing packaged operations and maintenance plans which are not specific to individual buildings. They are usually over-protective, stipulating that those in the building follow all precautionary procedures for that building, whether they are necessary or not. What are the peculiarities of buildings that result in different required OMP?

In many buildings the above-ceiling space is as large as four feet and the walls dividing the space of the building volume, with the exception of a few bearing walls, are changed below the hung ceiling, requiring no entry of personnel into the above-ceiling space in close proximity to the ACM. In many buildings there are few utilities above the ceiling; one can find only the electrical conduits and piping. Telephone lines are often in walls. These utilities rarely fail and when they do, repair by appropriately protected personnel is not difficult. The light bulbs in many hung fixtures in buildings are changed from below, not requiring entry above the hung ceiling. Supply air in many buildings is distributed in ducts from a centrally located fan. In some buildings there are local air supply units for suites. The units are hung in such a manner that they can be lowered to the floor for servicing. Others are at floor level below windows. These variations on building design have been observed in a selection of buildings. A hand-tailored Operations and Maintenance Plan (OMP) is required to guide maintenance and custodial personnel to take precautions when performing certain tasks in a specific building. In addition, work can be performed after hours, or at weekends if intrusion into the ACM matrix is a highly probable event. In this way, the building air will cleanse itself of any released fibers before occupants re-enter the building. O&M programs are easily integrated into maintenance procedures for a building. The person charged with maintenance becomes the Asbestos Manager for the building. The programs are not burdensome to maintenance personnel; the precautions to be taken for intrusion into the ACM are essentially the OSHA requirements for protection of personnel exposed above the Permissible Exposure Limit (PEL). This is for cases where substantial release is anticipated. OSHA has opined that maintenance workers are covered by the OSHA Construction Standard for Asbestos. Unfortunately, most building owners are either unaware of this or, if aware, have not complied. Only with a few very large buildings have the time demands on the Asbestos Manager been significant. The OMP procedures become routine and require less time as the individuals concerned become familiar with them. It is also possible to restrict activities associated with asbestos to a select number of the maintenance or custodial persons, an administrative practice used for control of occupational exposure to noise, for example.

Some myths remain. The myth of reentrainment of asbestos from ducts at return plenum velocities is still of concern. Velocities approximately 10 m/sec are needed for such reentrainment and these velocities do not exist in return plenums (Corn, 1967). Also of concern is the myth that gently removing a ceiling tile creates an episodic release of fibers of major proportions. Reports in the literature or undertaken as pilot studies do suggest that vigorous work above the ceiling creates worker breathing zone concentrations above the concentration 0.2 fibers per cc for short durations, but not greater than the 0.2 f/cc PEL (Time Weighted Average Concentration for 8 hours), because those who pull cables above the ceiling, for example, do so for a fraction of the day.

In summary, it is not necessary to remove asbestos because of the health risk it poses to occupants, and the health risk to maintenance and custodial personnel can be reduced to that associated with exposures well below the OSHA PEL, if simple precautions are taken. The issue of whether to keep the asbestos in the building and adopt an OMP for the remainder of building life or to remove it is an economic, rather than a health issue.

The Abatement Process

Removal necessitates extensive creation of dust. It is breaking up a solid ACM matrix and cleaning the underlying surface of the ACM. It is manually difficult work and requires extraordinary procedures to ensure the integrity of the so-called containment area around the removal zone. In this way, the spread of airborne contamination from the removal area to the surrounding areas does not occur. The abuses of the asbestos abatement industry have been documented in the literature of the industry (Sheridan, 1990). There has been television coverage of the exploitation by the industry of illegal immigrant labor. The past growth of the industry has also been documented and future growth has been projected (Weinick, 1990; Jennings, 1989). It is a very rapidly growing industry involving 5.2 billion dollars in 1989. The distribution of this money is 4.0 billion on contractor services, 800 million on environmental services and 400 million on equipment and supplies. The industry is projected to peak in 1993, with total services in excess of 8 billion dollars. By the year 2001 nearly 65 billion dollars will have been spent in the U.S. (Weinick, 1990). All this has occurred within 10 years.

Abatement at the End of Building Life

It is sometimes glibly stated that the ACM will have to be removed at the end of building life to meet requirements of the U.S. National Emission Standards for Hazardous Air Pollutants Standards (NESHAPS). If the present law remains in force this is true. However, removal of ACM at the end of building life when the building is not occupied, and when prior to demolition the ACM can be surgically removed without concern for putting the building together again, is a totally different matter than removal during active building life when the building must be reoccupied and reused. The process of removal at the end of building life is vastly more simplified.

Future Options

Thus far I have focused on the past and the present with regard to ACM in buildings. The key issue is what do we do next? There is apparently proposed legislation, similar to AHERA, for public buildings. Asbestos must be treated with respect. There should be requirements for surveying buildings to determine where the ACM is located, and the occupants of buildings should be alerted to its presence and informed of the measured concentrations of asbestos-in-air of that building. Occupants have a right to ask if they are breathing concentrations significantly in excess of those outdoors. The maintenance personnel in the buildings should be instructed in an OMP containing specific procedures relative to their building and the specific maintenance that they perform. Removal should not be encouraged in the approximately 750 000 U.S. commercial buildings containing ACM. It is unnecessary and will further expand the cohort of removal workers who are the most likely candidates for the next wave of asbestos disease. It is indeed conceivable that some building maintenance workers were adversely affected in the past when O&M procedures were not utilized. If OMPs are adopted in the future, there should not be excess asbestos disease among maintenance and custodial workers. There is still an enormous problem in getting removal workers to follow precautions and procedures established by law in many U.S. states. This requires more vigorous enforcement procedures.

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