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Area and Personal Airborne Exposure During Abatement of Asbestos-Containing Roofing Material

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Exposure to asbestos-containing material (ACM) is considered to be hazardous and can result in various occupationally related diseases (Health Effects Institute - Asbestos Research - HEI, 1991). This has resulted in establishment of regulations to protect those associated with this industry (Lange et al. 1996, Lange and Thomulka, 1995), although it has also been claimed that such abatement regulations are a public policy disaster in the US (Ross, 1995). The United States Occupational Safety and Health Administration (OSHA) has published regulatory standards for abatement of asbestos-containing roofing material (ACRM) and these requirements have been described in a Settlement Agreement with the roofing industry (OSHA, 1995). Under item 9 paragraph 1101(f)(2)(ii) as codified in 29 C.F.R. initial exposure monitoring is not required if a negative exposure assessment has been prepared (OSHA, 1995). Negative assessment by its self does not eliminate future air monitoring, but does allow an employer to consider that work activities of a same nature result in similar exposure levels (Lange et al. 1996). If such a negative assessment suggests exposure is below the OSHA permissible exposure limit (PEL), which is 0.1 fibers per cubic centimeter (f/cc) time-weighted average (TWA) (OSHA, 1995) many of the practices involving personal protection can be minimized. The most commonly referenced requirement involving personal protection is employment of a respirator (Lange et al. 1996). Thus, information about historical exposure levels can result in cost savings for those involved with abatement of ACRM (Lange et al. 1996). Currently there are few published studies of airborne exposure from asbestos during abatement (HEI, 1991; Lange et al. 1996; Lange and Thomulka, 1999) particularly roofing materials. Publishing exposure data can assist those in the abatement field in establishing historical information on exposure (Lange et al. 1996). This will allow development of a database for anticipated exposure during abatement of various materials and with different work practices (HEI, 1991).

This study reports on exposure concentrations for both area and personal measurements of airborne asbestos during abatement of roofing materials. These data provide information on historical exposure levels and compare the two sampling methods, area and personal sampling.

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MATERIALS AND METHODS

Air samples for determining exposure were collected during asbestos abatement of roofing materials (50,000 square feet) from a four-story building. This project was undertaken in Western Pennsylvania in the summer of 1999. The roof consisted of a double layer with a felt and tar underlayment. Flashing was also removed and met the definition of ACM. One roof was layered over the first roof. The age of these roof materials are approximately 20 to 30 years, respectively. Roof materials were identified as ACM by Polarized Light Microscopy and was estimated to be 5 - 10% chrysotile. Roof materials were abated by cutting out sections with a power saw. Work employed wet methods (HEI, 1991, OSHA, 1996). Water from a hose was used to wet the roof before abatement and when cuts were undertaken. Roof material was removed and placed into a chute (about 3 foot diameter). The chute was also periodically wetted and was connected into a dumpster. This dumpster was sealed, except the entering chute, with plastic and water from the hose was periodically applied to the dumpster via the chute to maintain material in a wet condition. However, due to the consistency of this roofing material wetting was not effective and some emissions occurred.

Area and personal air samples were collected with a 2 lpm (nominal) flow rate by the author (JHL) using a low flow pump (Lange et al. 1996). Samples were collected on 25-mm diameter electrically-conductive extension cowl cassettes with a mixed cellulose ester membrane filter and analyzed by Polarized Light Microscopy (PCM) (NIOSH 7400 method) (OSHA, 1996). Area samples were collected as close to the center of work as possible. Personal samples were collected from the breathing zone of an individual worker (OSHA, 1996). Sampling was conducted about every other day during abatement. Total time for abatement was about 25 days. Samples were non-matched (Lange et al. 1996).

Sample results were reported as summary statistics (Lange et al. 1996). Exposure measurements were evaluated for distribution (Shapiro-Wilk W test), outliers (Grubbs test), correlation (Pearson Product-Moment Correlation test - non-transformed) and difference between methods (non-transformed) (Wilicoxon Rank Sum test) (Lange and Thomulka, 1999). Confidence intervals (Cl), at 95%, were determined using a method for non-normal populations (Lange and Thomulka, 1999). Calculations were performed using actual numerical values (Lange, 1999). Sample concentration values that were reported below their detection limit was included in calculations at one half of the reported (detection limit) value (Oehlert et al. 1995). Statistical significance was defined at 5%.

Personal samples were evaluated for determination of a homogeneous or monomorphic population or group (Gardiner, 1995). An exposure group was considered to be homogeneous if 95% of its values are within 2 standard deviations or approximately 2 fold of the arithmetic mean (Lange and Thomulka, 1999). Probability (confidence coefficient) of exceeding the PEL for at least 5% of employees was evaluated using a graphic method (Leidel et al. 1977).

RESULTS AND DISCUSSION

Summary exposure results suggest occupational levels are low with no value numerically exceeding the OSHA PEL for airborne asbestos (Table 1). Exposure concentration for area and personal samples ranged from <0.0006 to 0.0162 f/cc and 0.0047 to 0.0752 f/cc, respectively. When these data are calculated into a TWA all values are below the PEL. Arithmetic mean concentrations for both area and personal measurements with each respective CI values, at the highest exposure level, were also well below the PEL. A single outlier, which was the largest value, existed for personal samples. No outliers existed for area samples. CI for area samples was +/-0.003 (range 0.003 to 0.009 f/cc) and for personal samples +/-0.011 (range 0.009 to 0.031 f/cc) without the outlier and +/-0.008 (range 0.007 to 0.028 f/cc) with the outlier.

Previous investigations (Lange et al. 1996) of airborne asbestos exposure have suggested that summary data should be presented as arithmetic mean, geometric mean (GM), standard deviation, geometric standard deviation (GSD), and range. The outlier identified in personal sample measurements had some influence on summary statistics. 'Since these data represent occupational exposure, it is suggested that summary data be presented with outliers (Lange, 1999). This would provide representation of the highest potential summary exposure to the worker population being evaluated.

There has been considerable discussion in the literature as to interpretation of exposure data (Lange, 1999). Most have considered that examination of individual exposure values should be used in determining whether the PEL is exceeded. An Appellant Court ruling on this issue (US Court of Appeals, 1991) suggested that the most appropriate form to represent exposure for evaluation against the PEL is GM (Letters to the Editor, 1998). Certainly if this summary statistic is not available then use of individual measurements would be appropriate (Letters to the Editor, 1998). Use of summary data for evaluation of exposure is particularly most appropriate for those toxicants that are considered chronic in nature (Seixas et al. 1998).

Both area and personal samples were non-normally distributed. These data best fit a logarithmic distribution, as has been suggested for airborne asbestos (Lange, 1999; Lange and Thomulka, 1999a) and other

Table 1. Summary statistics for area and personal sample concentrations, in f/cc (non-TWA), for abatement of roofing material.

Type of Sample	Number of Samples	Arithmetic Mean	Geometric Mean	Standard Deviation	Geometric Standard Deviation
Personal	13	0.020	0.013	0.020	2.82
	12+	0.015	0.011	0.014	2.53
Area	17	0.006	0.004	0.006	2.82

+ Values without outlier.

occupational contaminants (Gardiner, 1995). There was no correlation between sampling methods and concentrations were statistically different with and without the outlier. This suggests, as reported in other studies involving asbestos abatement (Lange, 1999) that area samples can not be employed to adequately represent occupational exposure. As suggested in other occupational studies (Lange, 1999; Lange and Thomulka, 1999, 1999a) personal air samples appear to best represent exposure to workers. However, employment of area samples for determination of occupational exposure is common in the abatement industry and will likely remain as a practice in the future (HEI, 1991; Lange et al. 1996).

Personal samples fall within the criterion of being defined as a homogeneous population and have an approximately probability of 35% for 5% of those employed exceeding the PEL. If the outlier is removed this probability is reduced to about 30%. Probability of at least 5% of the worker population exceeding the PEL is primarily due to the GSD. GSD values of 2.5 and 2.8 represent around 75 to 80% variation of day-to-day samples (Leidel et al. 1977). Even with this variation, exposure is well below occupational standards and any resultant exposure is not likely to be significant in asbestos disease causation (HEI-1991). Since there is an elevated rate of smoking in this population (Lange, 1992) these workers are at greater risk in developing “disease” from such personal habits than from occupational exposure to asbestos (HEI, 1991).

Homogeneity of this group based on exposure suggests that roofers conducting asbestos abatement work can be placed in a single classification (Gardiner, 1995). This finding suggests that exposure to one individual within the group would be representative of all members of the population. However, the small number of samples, reported variation for samples and observations consisting of a single abatement project must temper these finding.

This study provides exposure data that can be classified, in part, as historical information for those performing abatement of ACRM (HEI, 1991, Lange, 1999; Lange and Thomulka 1999, 1999a). However, these data must be evaluated with caution since it represents a small population of samples and information from only one abatement project. This investigation supports the Settlement Agreement of the roofing industry and OSHA (OSHA, 1995) for minimizing requirements involved with abatement. Based on these data, less controls than that suggested in the Settlement Agreement may be applicable. Summary exposure values suggest minimal likelihood of elevated concentrations of asbestos during roof abatement. In addition, it has been suggested that PCM methodology may overestimate exposure, although some caution must be applied since this method does not count" fibers below 5 um in size (Mlynarek et. al. 1996).

Exposure data suggest that respirator use would not be required during abatement of ACRM (OSHA, 1996). Asbestos abatement specifications often require employment of respirators without consideration of previous exposure levels (historical/objective data) (Lange, 1999). Some have suggested that at low levels of exposure employment of negative pressure respirators may exhibit a greater hazard to the worker from physiological stress that from exposure to the "identified hazard" which it's use is designed to provide protection (Lange, 1999; Lange and Thomulka, 1999).

This study suggests that exposure to asbestos during abatement of roofing materials is low. No single exposure value exceed the PEL for asbestos. There was no correlation between area and personal samples. Personal samples were reported to have a statistically higher exposure concentration than area samples and are suggested to be the best measure of occupational exposure. Airborne concentrations of asbestos were non-normally distributed and exhibit a large variation. Additional investigations are warranted on exposure generated during various types of asbestos abatement.

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