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Air Sampling During Asbestos Abatement of Floor Tile and Mastic

J. H. Lange,[1] K. W. Thomulka[2]

[1] Envirosafe Training and Consultants, Post Office Box 114022, Pittsburgh, PA 15239: USA
[2] University of the Sciences in Philadelphia, 600 South 43rd Street, Philadelphia, PA 19104, USA

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Asbestos abatement is a major industry in the United States (Lange et al. 1996). Health investigations have reported that inhalation of asbestos can result in respiratory related diseases (Health Effects Institute - Asbestos Research - HEI-AR, 1991). Little information has been published on exposure concentrations for abatement of specific types of asbestos-containing materials (ACM) (HEI-AR, 1991). Traditionally, area and personal samples have been suggested not to be related (Sherwood, 1966; Stevens, 1969; Leidel, et al. 1977) although a limited number of publications have reported a potential relationship for these two sampling methods (Breslin et al. 1967; HEI-AR, 1991; Lange et al. 1996). Studies suggesting no association were conducted for non-abatement industries. Area samples are commonly used to substitute for personal measurements especially in the abatement industry (Lange et al. 1996). Regulatory standards do not recognize area measurements as a method for determining worker exposure (Lange et al. 1996).

This study reports on exposure concentrations during an asbestos abatement project conducted in 1997. Area and personal samples were compared to evaluate if any relationship exists between these two sampling methods.

MATERIALS AND METHODS

Exposure measurements, area and personal samples, were collected during asbestos abatement of floor tile and mastic in a three story dormitory type building (25,000 square feet-abated) in Pennsylvania, USA. Floor tile and mastic were both identified as ACM by polarized light microscopy (PLM). Asbestos was determined to be of the chrysotile variety and was between 3-7% for both types of materials. Collection of samples was by an independent technician. This technician selected workers to be monitored and the locations for area samples. During some days little or no abatement occurred (e.g. setup). Results are reported for time periods of abatement. The time period of abatement activities, including setup and final air clearance, was about 20 days.

Correspondence to: J. H. Lange

Both area and personal samples were collected using low flow air sample pumps. Sample rate for both types of measurements was (nominal) 2 lpm as previously described (Lange et al. 1996). All samples were collected using 25 mm diameter electrically-conductive extension cowl cassettes with a mixed cellulose ester membrane filter and analyzed by the NIOSH 7400 method, which uses phase contrast microscopy (PCM) (Lange et al. 1996).

Area and personal samples were reported as actual concentration values and as a time-weighted average (TWA) as previously described (Lange et al. 1996; Occupational Safety and Health Administration - OSHA, 1998). Sample data were evaluated for both types of samples using the actual concentration value (non-TWA). Some sample results were below the detection limit as determined by the volume of air collected. These sample concentrations were included in calculations as one half of the reported value (Oehlert et al. 1995). Data were reported as summary statistics (Lange et al. 1996). Distribution and outliers were evaluated using the Shapiro-Wilk W test (W test) and Grubbs test (Gilbert, 1987), respectively. Statistical evaluation for comparison of area and personal samples (non-matched) was performed using the Wilicoxon Rank Sum test (Gilbert, 1987). Correlation was conducted using the Pearson Product-Moment Correlation test (Gilbert, 1987). Both the Rank Sum and Correlation tests were performed using a computer program (Timko and Downie, 1992). Statistical significance was defined at 5% unless otherwise noted.

Abatement practices were conducted as described by OSHA and Environmental Protection Agency. Floor tile abatement (removal) was performed using scrape and lift and mastic by chemical solvent. Little water was used for abatement of floor tile. Engineering controls consisted of employment of negative air machines with an exchange rate of at least four changes per hour. Polyethylene barriers (6 mil) and a three stage decontamination station were employed. Final clearance samples were collected upon final cleaning as previously described (Lange et al. 1996).

RESULTS AND DISCUSSION

Airborne asbestos concentrations for both area and personal measurements are shown in Table 1. These data suggest a large range of concentrations. For both types of measurements the highest non-TWA values corresponds to the largest TWA concentration. All TWA and non-TWA measurements are below the OSHA Permissible Exposure Limit. Four values were below the detection of limit for personal samples and one for area samples.

Table 1. Concentration, in f/cc, of airborne asbestos during abatement of floor tile and mastic.

Type of Sample	Total Sample Time (minutes)	Sample Concentration	8 hour TWA Concentration
Personal	231	0.034	0.017
Personal	217	0.025	0.011
Personal	196	0.094	0.021
Personal	57	0.036	<0.01
Personal	192	<0.014	<0.01
Personal	120	<0.012	<0.01
Personal	344	0.015	<0.01
Personal	156	<0.009	<0.01
Personal	115	0.055	0.013
Personal	271	0.035	0.019
Personal	177	<0.008	<0.01
Area	100	0.026	<0.01
Area	86	0.018	<0.01
Area	152	0.008	<0.01
Area	393	0.007	<0.01
Area	118	0.02	<0.01
Area	171	0.016	<0.01
Area	88	0.067	0.012
Area	210	0.010	<0.01
Area	109	0.008	<0.01
Area	347	0.002	<0.01
Area	325	0.002	<0.01
Area	200	0.002	<0.01
Area	117	0.004	<0.01
Area	326	<0.002	<0.01

Summary results are shown in Table 2. These data suggest that personal samples exhibit a higher concentration than area values. Geometric means are smaller than arithmetic means for both types of measurements. Standard deviation is larger for personal samples than area samples, but its geometric standard deviation is smaller than that of area measurements.

Both area and personal samples were non-normally distributed when evaluated as non-transformed. When transformed these data were both normally distributed, suggesting a logarithmic form (Leidel et al. 1977; Lange et al. 1996). The largest concentration value for both measurements (area 0.067 f/cc and personal 0.094 f/cc) was an outlier.

Table 2. Summary statistics for area and personal sample concentrations, in f/cc (non-TWA), for abatement of floor tile and mastic.

Type of Sample	Number of Samples	Arithmetic Mean	Geometric Mean	Standard Deviation	Geometric Standard Deviation
Personal	11	0.029	0.018	0.026	2.81
	10+	0.022	0.015	0.017	2.54
Area	14	0.014	0.007	0.017	3.14
	13+	0.010	0.006	0.008	2.73

+ Values without outliers.

For personal samples the highest value was an outlier at a 5% level, but not at 1%. The largest value for area measurements was an outlier at both 5% and 1% levels. Personal samples were statistically higher in concentration than area samples with and without outliers. Previous studies comparing area and personal sample results have reported personal samples as having the highest concentration value (Sherwood, 1966; Stevens, 1969; HEI-AR, 1991; Lange et al. 1996). Sampling methods were not correlated and were statistically different.

These sample data suggest that area and personal samples are not related and area samples can not be used in place of personal measurements (Lange, 1999). Personal samples are suggested to be the best measurement method for determining exposure to abatement workers (Lange et al. 1996). Abatement of floor tile and mastic is suggested to result in exposure that is below the OSHA Permissible exposure Limit of 0.1 f/cc-TWA (Lange and Thomulka, 1999). OSHA regulations require controls and use of respirators when performing abatement on this type of material (OSHA, 1998). These data do not support the use of respirators and employment of limited control measures would appear to be appropriate. Regulations requiring employment of "full" engineering controls and respiratory protection, based on these and other exposure data for floor tile and mastic (Lange and Thomulka, 1999), could be categorized as legislating science. Use of respirators below a "hazardous" exposure level has been suggested to result in increased physiological stress to the wearer (Raven et al. 1979). Additional investigation of exposure levels associated with abatement of different types of ACM and comparison of area and personal sample measurements are warranted.

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