Bull. Environ. Contam. Toxicol. (2005) 74:388–390

DOI: 10.1007/s00128-004-0596-5

Bulletin of Environmental Contamination and Toxicology

Area and Personal Exposure Measurements During Asbestos Abatement of a Crawl Space and Boiler Room

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Received: 12 July 2004/Accepted: 1 November 2004

A debate exists as to the hazard associated with removal of various asbestos-containing materials (ACM) (Lange, 2004). Unfortunately, there have not been many published exposure studies during abatement of specific ACM (Lange, 2004). Pipe insulation in crawl spaces is often a form of asbestos called "air-cell" insulation. This ACM is generally around 35-60% asbestos and commonly consists of a mix of chrysotile and amosite types of asbestos. Boiler insulation is generally lower in asbestos concentration, which is more commonly of the chrysotile variety.

This investigation reports on area and personal exposure measurements during removal of pipe insulation in a crawl space and boiler insulation. A comparison of area and personal samples is presented.

MATERIALS AND METHODS

Exposure data were collected during an actual asbestos abatement project that was performed in the early 1990's and involved removal of insulation from pipes in a crawl space and associated boiler room (boiler). Abatement practices followed the Occupational Safety and Health Administration (OSHA) requirements; although wetting of material was not always conducted as required.

Area samples were collected using a high volume pump while personal samples were collected from the breathing zone as previously described (Lange et al., 2000). Samples with less than 110 minutes of sampling time were not included in the analysis. Counts of asbestos fibers (fibers/cubic centimeter–f/cc) were conducted using phase contrast microscopy (PCM). Exposure data were calculated as a time-weighted average (TWA).

Statistical comparison between area and personal measurements was performed using the Wilcoxon-rank test and distribution was determined with the Shapiro-Wilk test. Identification of outliers was performed by the Box-Cox method. To determine whether the mean personal exposure was less or above than the Permissible Exposure Limit (PEL), the T test was conducted according to Rappaport (1987), where the mean (μ_l) and

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the standard deviation (σ_l) of the log-transformed values were combined in order to evaluate a maximum likelihood estimate of the mean exposure (x_c) from a lognormal distribution. All statistical analysis was conducted using SPSS (2003), except for the T test. Significance was set at 0.05.

RESULTS AND DISCUSSION

Results (f/cc-TWA) are reported in the table 1 as summary exposures (arithmetic mean-AM, mean from a lognormal distribution-x_c, and geometric mean-GM, standard deviation-SD, geometric standard deviation-GSD (Lange et al., 2000). Area and personal data were non-normally distributed when untransformed, while personal samples were normal when log-transformed with area samples remaining non-normal. Previous studies (Lange et al., 2002) on airborne asbestos concentrations have reported that these values best fit a lognormal distribution. Area and personal samples had eight and one outliers, respectively, with all of these values belonging to the highest measurements. No statistical difference exists between area and personal samples ($p < 0.83$). This suggests that both sampling methods collected fibers from the same airborne population. Other studies (Lange et al., 2000) have reported that personal samples are statistically greater than area samples. Comparison of studies on area and personal measurements (Lange et al., 1996) suggests that whether these sampling methods will provided similar exposure results are most likely related to the work practices and engineering controls. However, it should be noted that OSHA requires that evaluation of exposure be performed by personal measurement. A number of studies (Lange et al., 1996; 2000) have been conducted evaluating personal and area measurements with most reporting that area measurements can not be used as a substitute for personal samples.

In this study, engineering controls were effective in maintaining an average exposure level at the PEL. Even though the T test result of 0.07 ($p>0.90$) suggests that the personal exposure did not exceed the OSHA PEL of 0.1 f/cc-TWA, an over-exposure was possible. It has been suggested (Lange and Thomulka, 2000) that when exposure levels are below the PEL use of respirators is inappropriate and that use could create a detriment.

Since asbestos is a long-term toxicant, mean summary exposure are suggested to best represent potential for disease (Armstrong, 1992). This is supported by Rappaport (1987), who suggested the geometric mean is not a physiological significant endpoint, while x_c is a more efficient estimate because is dependent upon both μ_l and σ_l. However, a United States Court of Appeals (1991) lead case recommended that for regulatory purposes exposure be represented as the GM. The minimum threshold for asbestos disease was presumed at 5 f/cc/lifetime (f/l) (Ilgren, 2001; Lange, 2004). If the GM value (about 0.03) is used in determining a lifetime exposure, which can be set at 45 years, the cumulative exposure is 1.35 f/l.

Table 1. Summary statistics for air samples, in f/cc-TWA

Type of sample	N° samples	AM	x_c	GM	SD	GSD	Range
Personal+	45	0.08	0.10	0.03	0.11	4.8	<0.01-0.55
Area+	97	0.09	0.11	0.03	0.15	5.0	<0.01-0.75

+ there is no statistical difference between area and personal

Even when the x_c is used (about 0.1 f/cc), the f/l value does not exceed the presumed threshold level (=4.5 f/l). According to Boffetta (1998), at this cumulative exposure the risk of lung cancer could increase by 4.5% (i.e., from 1.000 to 1.045), while, according to either Selikoff (1979) or Finkelstein (1983) respectively, the increase in risk of mesothelioma could range from 0.00045% to 0.0054% (i.e., from 1.000000 to either 1.0000045 or 1.000054).

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