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Beryllium Contamination Inside Vehicles of Machine Shop Workers

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INTRODUCTION

Inhalation of beryllium particles causes a chronic, debilitating lung disease in immunologically sensitized workers [Eisenbud and Lisson, 1983]. Evidence that very low concentrations of beryllium may initiate this chronic disease is provided by occurence of the illness in family members exposed to beryllium dust from workers' clothes [Eisenbud et al., 1949]. Although workplace beryllium concentrations have decreased dramatically in the U.S. since chronic beryllium disease (CBD) was first described in the 1940s, it continues to occur and has recently been documented in family members of beryllium-exposed workers [Newman and Kreiss, 1992]. CBD has not been associated with take-home beryllium exposures in other countries, suggesting that beryllium exposures are lower internationally than in the U.S. or possibly the disease has been unrecognized.

A cross-sectional survey was conducted to evaluate potential take-home beryllium exposures of workers at a precision machine shop manufacturing beryllium products, where seven cases of CBD had recently been diagnosed. Over 200 workers were employed at this plant and many of them did not change out of their work clothes at the end of the workday and often used their personal vehicles during the work shift without changing clothes. These work practices served to increase the risk of exposing workers' family members to beryllium.

METHODS

To evaluate whether workers were carrying beryllium home, wipe samples were collected using commercial wet wipes (Wash'n Dri-Moist Towelettes^{TM}) from workers' hands as they were leaving work and inside their personal vehicles. For estimation of background beryllium levels, wipe samples were collected inside control vehicles belonging to individuals with no beryllium exposure from other workplaces in the vicinity of the plant. These vehicles belonged to hotel, restaurant and construction workers. The dimensions of the wiped surface area were measured and a single wet wipe was firmly drawn across the surface by using a series of horizontal strokes, followed by vertical strokes, and finally a series of diagonal strokes, for a total of three passes over the surface area sampled [NIOSH, 1994].

Samples were analyzed for beryllium using inductively coupled argon plasma–atomic emission spectroscopy (ICP–AES) according to NIOSH Method 7300 with the results reported in micrograms of beryllium per square foot ($\mu g/ft^2$). The estimated limit of detection (LOD) for this method was 0.01 micrograms (μg) of beryllium per sample. Although the sampling technique has limitations, it was applied consistently for all survey participants. No legally mandated health standards for beryllium surface contamination nor beryllium measurements from the hands and vehicles of other workers are available to compare with measurements collected in this study, but some facilities have used 25 $\mu g/ft^2$ as an index of cleanliness for beryllium surface contamination [DOE, 1992].

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RESULTS

Sixty-one workers were randomly selected to participate in the study. About 80% of the workers reported that they always or usually changed their shirt before going home or wore a shop coat over street clothes while working. Slightly over half of the workers changed their work pants and shoes before going home. Yet, 40% of the workers reported using their vehicle during lunch breaks without changing clothes or shoes. Although all of the workers reported washing their hands before going home, none of the workers showered before leaving work.

Observation confirmed that workers frequently wore contaminated clothing inside their vehicles. Even infrequent wearing of beryllium-laden clothing inside the vehicles could result in substantial contamination over time. Among workers who did change clothes, street clothing was possibly contaminated because the locker rooms were designed such that street clothes could contact beryllium contaminated clothing or work areas. Workers reported that due to working overtime shifts, they sometimes did not have enough clean uniforms for every workday.

The beryllium concentrations detected on wipe samples from inside workers' vehicles and control vehicles are presented in Table I. The greatest amount of beryllium was found on the driver's floor (GM = 19 μg/ft^2, GSD = 4.9). The measurements from all locations varied across a wide range, up to several hundred μg/ft^2 in some workers' vehicles. Only 29 dashboard samples were collected and the levels were relatively low with only one sample exceeding 25 μg/ft^2. No beryllium was detected on samples from three child safety seats that were tested. Beryllium was detected in 21 of the 70 (30%) wipe samples collected from ten control vehicles, but only one sample from the floor of a roofer's vehicle exceeded 1 μg/ft^2.

Beryllium concentrations from handwipe samples are presented by job category in Table II. Beryllium was detected on the handwipe samples from all of the machining, lathe, and deburring operators. In comparison, only two of six office workers had detectable, yet low, beryllium concentrations on their handwipes. The amount of beryllium on handwipe samples was somewhat correlated with beryllium concentrations on samples from the steering wheel ($r = 0.45$, $P = 0.0003$) and driver's armrest ($r = 0.41$, $P = 0.001$).

TABLE II. Beryllium Concentrations on Hand Wipe Samples by Job Area

Job area	No. of samples	GM (GSD) μg/ft^2	Maximum concentration μg/ft^2
Milling	16	6.3 (2.3)	19
Lathe	6	8.0 (2.9)	30
Grinding	3	5.6 (1.0)	5.8
E-Cell	4	30 (1.9)	54
Lapping	12	2.3 (2.7)	10.7
Debur	2	21 (1.5)	29
Production Support	12	4.5 (4.2)	43
Office	6	1.0 (1.1)	1.3

GM = geometric mean
GSD = geometric standard deviation

TABLE I. Beryllium Concentrations Inside Machine Shop Workers' Vehicles and Control Vehicles by Location

	Wipe samples from machine shop workers' vehicles				Wipe samples from 10 control vehicles	
Location	No. of samples	GM (GSD) μg/ft^2	Maximum concentration μg/ft^2	% Samples >25 μg/ft^2	No. of Samples >LOD	Maximum concentration μg/ft^2
Steering Wheel	61	2.3 (2.9)	49	3.3	1	0.03
Driver's Armrest	61	4.5 (4.9)	369	9.8	2	0.07
Driver's Seat	61	2.4 (3.7)	148	6.6	1	0.006
Driver's Floor	61	19 (4.9)	714	44.3	6	2.1
Passenger's Seat	61	1.7 (2.9)	70	4.9	3	0.04
Passenger's Floor	61	4.9 (5.7)	234	21.3	3	0.06
Dash	29	1.9 (2.9)	40	3.4	5	0.13
Child Seat	3	< LOD	<LOD	0.0	–	–

GM = geometric mean
GSD = geometric standard deviation
LOD = analytical lower limit of detection for beryllium

DISCUSSION AND CONCLUSIONS

Beryllium samples collected inside the control vehicles indicated that background beryllium contamination from environmental sources is very low. Since a safe or recommended minimum concentration of beryllium on the surfaces of hands and automobiles is not known, it is difficult to evaluate the health risks associated with the levels found for the workers at this machining plant. But as an indicator of take-home exposures and increased risk for family members to inhale beryllium, it is prudent to reduce surface concentrations and the potential for workers to carry beryllium away from the work site. Therefore, the wipe sampling results—showing that many workers both carried residual beryllium on their hands when leaving work and had contaminated the inside of their vehicles—were presented to the workers and company management.

Based on NIOSH recommendations, the company redesigned the locker rooms, requires all workers to wear coveralls and work shoes while working inside the plant, and to shower before changing into their street clothes and shoes. To date, no cases of CBD have been diagnosed in family members of workers at this particular plant.

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