

## DIOXIN-LIKE COMPOUNDS IN WORKERS AT A PRIMARY MAGNESIUM PRODUCTION FACILITY

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### Abstract

Biomonitoring data was collected for workers at a primary magnesium production facility as a part of a Health Hazard Evaluation (HHE) conducted by the U.S. National Institute of Occupational Safety and Health (NIOSH). The HHE included the measurement of dioxin-like compounds (DLCs) in blood of 30 workers believed to have the greatest potential for exposure. Lipid-adjusted DLC serum levels measured as a part of the HHE were compared to background levels observed in the general U.S. population using two techniques: 1) comparison of mean and maximum concentrations in the HHE report to published reference values and, 2) comparison of individual results to the 95<sup>th</sup> percentile and maximum value for 2001-2002 male NHANES participants ages 40-59 years. Analyses indicated that the levels of DLCs, expressed on a TEQ basis, for all 30 workers were below the maximum value for 40-59 year olds in the NHANES dataset. To this extent, site-related exposures to DLCs do not appear to have resulted in increased body burdens in these workers.

### Introduction

Biomonitoring data is increasingly being used to assess potential human exposures to a variety of chemicals. In November 2004, the U.S. National Institute of Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation<sup>1</sup> (HHE) to evaluate the exposure of workers to a number of compounds, including dioxins, furans and PCBs, at a primary magnesium production facility in Rowley, Utah. One of the principal objectives of the HHE was to determine blood levels of dioxin-like compounds (DLCs) in a sample of workers who had the longest tenure at the facility and worked in areas with the greatest potential for formation of DLCs in an effort to assess potential exposure as a result of their daily job duties. However, because DLCs are ubiquitous environmental contaminants that bioaccumulate in the environment, they have been detected in the tissues of a variety of species including humans<sup>2</sup>. As such, when evaluating potential exposures to DLCs, it is necessary to compare measured levels to typical reference levels of the general U.S. population for proper context. The U.S. Centers for Disease Control and Prevention and National Center for Health Statistics conducts a comprehensive nationwide biomonitoring study, the National Health and Nutrition Examination Survey (NHANES), to collect data on referent levels of a variety of contaminants in human tissues. As such, the NHANES dataset provides a useful tool for evaluating levels of DLCs measured in potentially exposed populations. Using serum levels of DLCs measured as part of the 2001-2002 NHANES survey, we evaluated the levels of DLCs in workers at this facility and determined if they were similar to referent levels established for the general U.S. population or if the levels were elevated and suggestive of exposures at the facility. A secondary goal was to determine if comparison to published reference values yielded results that were similar to those of NHANES participants of the same age and gender.

### Materials and Methods

The biomonitoring data collected for the primary magnesium production plant workers as part of the NIOSH HHE (HETA#2004-0169-2982) was requested and obtained from NIOSH. The congener-specific data for each individual was analyzed using the 1998 Toxic Equivalency Factors (TEFs) developed by the World Health Organization (WHO)<sup>3</sup>. All DLCs identified by the WHO<sup>3</sup>, with the exception of PCBs 77, 114, and 123, were included in these analyses (i.e. the 17 laterally-substituted polychlorinated dibenzo-p-dioxins and dibenzofurans + the 3 coplanar polychlorinated biphenyls (PCBs) + the 6 mono-ortho PCBs). PCBs 77, 114, and 123 were not included because these congeners were not measured in the 2001/2002 NHANES survey.. Lipid-adjusted serum concentrations were determined for each DLC provided in the dataset and the total 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalency quotient (TEQ) was determined for each individual by applying the WHO TEF to the lipid-adjusted serum concentration and then summing the TEQs for each congener. In cases where a congener was reported as non-detect, a value equivalent to the detection limit divided by the square root of two was imputed to be consistent with the approach used to calculate reference values previously published. The total TEQ for each individual was then evaluated using two techniques: 1) comparison of

mean and maximum concentrations in the HHE report to published reference values in Patterson et al. (2004)<sup>4</sup> and Ferriby et al. (2006)<sup>5</sup> and, 2) comparison of individual results to the 95<sup>th</sup> percentile and maximum value for 2001-2002 male NHANES participants ages 40-59 years. All analyses were conducted using SAS and SUDAAN software.

### Results and Discussion

The first step in evaluating the DLC body burden of workers included in the NIOSH HHE study included comparing the summary data provided in the HHE report to reference values published by Patterson et al. (2004)<sup>3</sup> and Ferriby et al. (2006)<sup>4</sup>. In making these comparisons, it is important to note that the values provided in Ferriby et al. (2006)<sup>4</sup> may be more representative of the general, non-institutionalized U.S. population as they are based on nationwide data gathered as a part of the 2001-2002 NHANES, whereas the values presented in Patterson et al. (2004)<sup>3</sup> are based on data from 588 individuals in four states. When summary statistics presented in the HHE report were compared to the published reference values presented in Patterson et al. (2004)<sup>3</sup> and in Ferriby et al. (2006)<sup>4</sup>, the mean lipid-adjusted TEQ for all 30 workers exceeded the mean reference values, while the maximum value for the workers was within the range of published ranges (Table 1). For example, total TEQ for the workers ranged from 12 to 147 ppt (mean=37.3 ppt), whereas total TEQ of the general U.S. population, based on 2001-2002 NHANES data, ranged from 8 to 208.1 ppt (mean=30.4 ppt)<sup>4</sup>. However, there are a number of challenges posed by these comparisons. First, the DLCs NIOSH considered in developing summary statistics in the HHE report were not clearly identified and, as such, there is uncertainty as to whether they are consistent with those used to develop the published reference values. Second, the age groups developed by NIOSH as presented in the HHE report, are not directly comparable to those used to develop the published reference values. Third, since the NIOSH report only included limited summary statistics (i.e., mean, minimum, and maximum values), it is not possible to conduct more robust analyses to determine how the total TEQ of each individual compares to reference levels.

The next step involved comparing the total TEQ for all dioxin-like congeners (i.e., 17 laterally-substituted PCDDs and PCDFs + 3 co-planar PCBs + 6 mono-ortho PCBs) measured in each individual to the 95<sup>th</sup> percentile and maximum value for 2001-2002 NHANES participants of the same age and gender (i.e., males aged 40-59 years). As indicated in Figure 1, the total TEQ for the majority of facility workers evaluated by NIOSH were below the 95<sup>th</sup> percentile of NHANES. Indeed, only 7 individuals exceeded the 95<sup>th</sup> percentile and none were above the maximum value determined for male NHANES participants aged 40-59 years.

These results indicate that the levels of DLCs, expressed on a lipid-adjusted total TEQ basis, for all 30 workers evaluated as a part of the NIOSH HHE (i.e., workers performing jobs believed to have the greatest potential exposure with the longest tenure at the primary magnesium production facility) were within the range observed for the general, U.S. population. Furthermore, the levels of DLCs measured in these workers were at least one order of magnitude lower than levels measured in exposed populations reported in the peer reviewed literature, which often range upwards of 1,000 and in some cases 10,000 ppt<sup>6,7</sup>. In conclusion, this evaluation of the NIOSH HHE data indicates that site-related exposures to DLCs do not appear to have resulted in increased dioxin body burdens in these workers.

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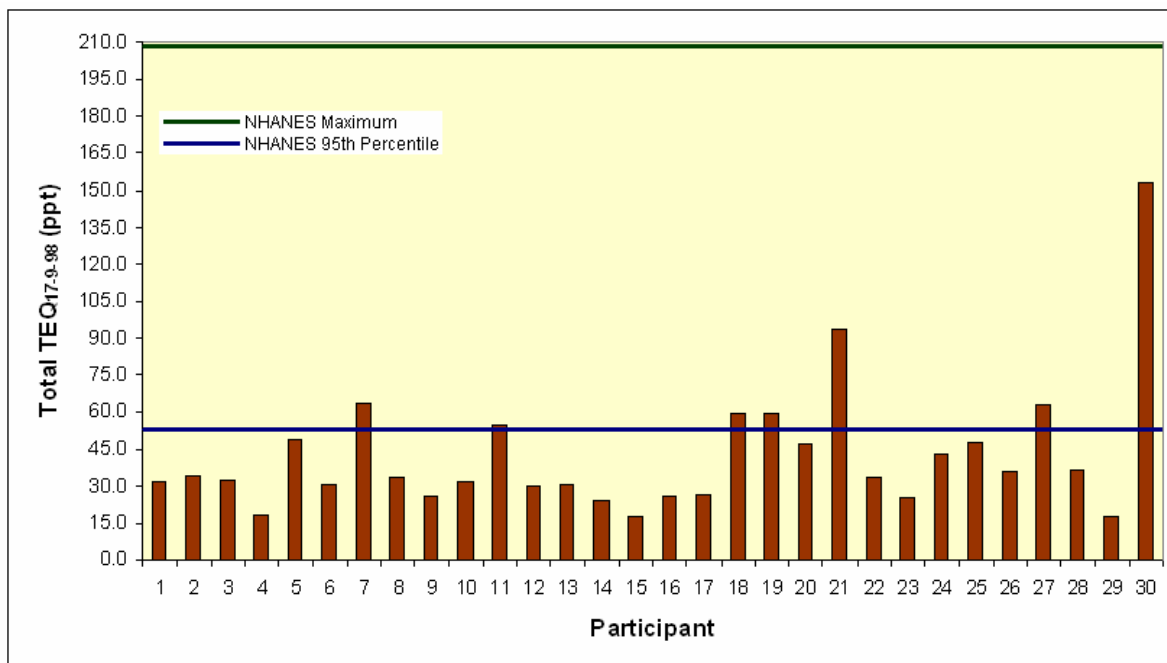
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**Table 1.** Comparison of summary statistics for the levels of dioxin-like compounds in the workers at a primary magnesium production facility to published reference values for the general U.S. population.

Study	Years of Collection	N	TEQ (ppt lipid)		
			Mean	Min	Max
<b>Magnesium Facility Cohort (NIOSH HHE, Table 5)</b>					
All	2004	30	37.3	12	147
40-44		3	20.95	13.8	34.6
45-49		10	28.9	17.1	58.6
50-54		10	37.4	12	89.5
55-59		7	53.2	26.1	147
<b>Patterson et al. 2004 (Compilation of studies from 4 states)</b>					
All	1996-2001	588	16.8	0	146.4
30-44		199	11.8	0.2	50.4
45-59		160	16.9	0.8	55.4
<b>Ferriby et al. 2006 (Table 1c - based on 2001-2002 NHANES)</b>					
All	2001-2002	1081	30.4	8	208.1
30-44		305	22.9	10.4	117.2
45-59		228	31.4	10.3	208.1

Note: the number of dioxin-like congeners included in the TEQ evaluation may not be the same for all studies in Table 1. While both the Patterson et al. (2004) and Ferriby et al. (2006) publications both clearly identified the specific congeners included in the TEQ calculation, the NIOSH report was not clear as to which congeners were included in their TEQ calculation.

**Figure 1.** Comparison of levels of dioxin-like compounds for individual workers at a primary magnesium production facility to the 95<sup>th</sup> percentile and maximum value for 40-59 year old male participants of the 2001-2002 NHANES\*



\*Based on application of the 1998 TEFs to data for 40-59 year old males in the 2001-2002 NHANES dataset