DRAFT

Examination of Diesel Particulate Matter (DPM) Compliance Samples in the Metal/Nonmetal Mining Industry

Background & Methods:

This paper presents the results of an analysis of DPM compliance samples using data collected by the Mine Safety and Health Administration (MSHA). The purpose of the current document is to support discussion at the upcoming Partnership meeting. Thus, the results of the data analysis are presented here without any discussion or commentary.

The MSHA database of compliance samples provides information on compliance with the interim and final personal exposure limit (PEL). Although the data are collected for compliance purposes, and not as part of a survey using a sampling strategy which would provide representative data of industry-wide compliance, the present data do provide a snapshot of the relative success or failure to reduce DPM exposure levels to specified target values. These data cannot be used to determine the efforts that were taken to reduce DPM; however, it would be reasonable to assume that mines made an earnest effort to avoid a citation for being out of compliance with the interim PEL. Currently, the data collected by MSHA provide the best data set available, and we believe there are useful insights to be gleaned from the analysis of these data.

The data used for this analysis were compliance data collected by MSHA between July 2003 and June 2005. To facilitate a comparison between these two years, the data were divided into two parts: (1) July 2003 through June 2004; and (2) July 2004 through June 2005. There were 1,507 available samples; however, 14 of the samples were excluded from the analysis because they were taken at surface locations. The final data set consisted of 1,493 samples; 402 were metal mine samples, 90 were nonmetal mine samples, and 801 were stone mine samples. There were 32 samples with a value of zero. Because these "zero" samples presented computational problems, they were converted to nonzero values by: (1) choosing an arbitrary but small limit of detection (L) of 10 DPM; and (2) substituting a value of $L/(2^{.5})$ as recommended by Hornung and Reed (1990) when sample data with an estimated geometric standard deviation (GSD) are less than 3.0.

One analysis approach that can be used with these data is to compare the samples collected at each mine to the interim and final PEL. If all samples from a mine are below the PEL, then the mine would be classified as "able to comply". The weaknesses of this approach are twofold. First, this test of ability to comply could be considered unreasonably strict because a mine may have numerous samples which are in compliance, with only one sample which is out of compliance, and the mine would be labeled as unable to comply. Second, this approach fails to consider how far out of compliance the samples are, for example, samples that just miss the PEL are treated in the same manner as samples that are significantly higher than the PEL. Yet, the extent to which a sample missed the PEL is important from a control perspective.

To address the aforementioned weaknesses, an alternative analysis approach was employed. The mine-level test was eliminated, and the results were reported as the number of samples within a certain compliance range rather than the number of mines. An "exceedance test procedure" was used to give a different weight to samples that were close to the PEL as opposed to those that exceeded the PEL by a larger amount. This procedure was used to calculate an exceedance fraction, which is an estimate of the fraction of exposures that are expected to exceed an occupational exposure limit (OEL). The data set of MSHA compliance samples was considered to be a random set of samples from a log normally distributed exposure profile.

The first step was to establish a target exceedance fraction. The choice of a target exceedance fraction is typically a policy decision based on the relative hazard of the contaminant being examined and the potential error in the measuring methods. A target exceedance fraction of 5% is considered protective and reasonable in other NIOSH evaluations, although it should be noted that in other difficult applications, such a noise exposure in the military, a 10% target is used. Next, a confidence limit needed to be selected. A 90% confidence interval is considered a statistically reliable range of confidence for the estimated values. The relevant portion of this confidence interval for determining whether the target exceedance rate of 5% has been met would be the 95% upper confidence limit. For this examination of the data, compliance will be met when exceedance fractions are less than 5% at the 95% upper confidence limit. One limitation of this approach is that the accuracy of the method depends greatly on the sample size. While a point estimate can be made at sample sizes as small as 2, only sample sizes greater than 9 are considered to have reasonable confidence intervals for the purpose of this evaluation. Procedures for computing confidence intervals around these exceedance fractions followed the methods proposed by Hewett and Ganser (1997) and are valid for sample sizes ranging from 2 to 1000.

Results

The following figures illustrate the exceedance fraction and the confidence interval for the samples. Different levels of stratification, e.g. sector, commodity, mine, and job type, are used in an effort to understand the status of compliance throughout the metal/nonmetal industry. Finally a set of figures is used to illustrate predicted exposure levels for selected exceedance fraction targets.

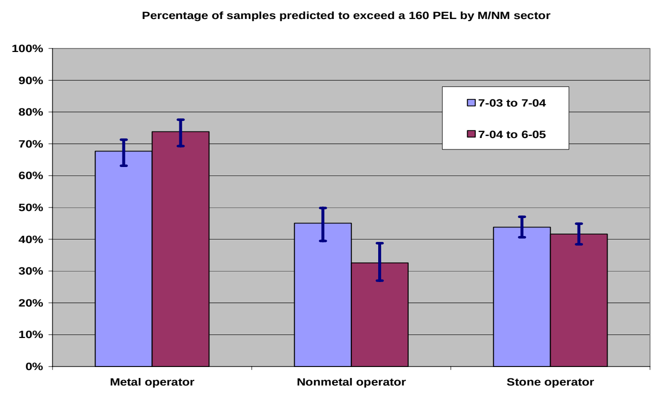

Figure 1

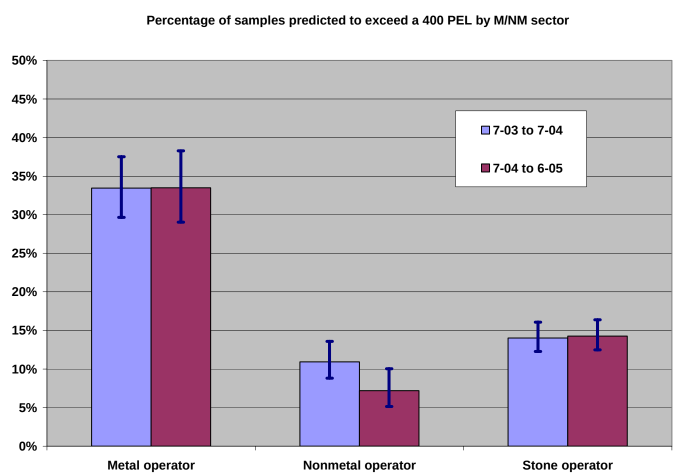

Figure 2

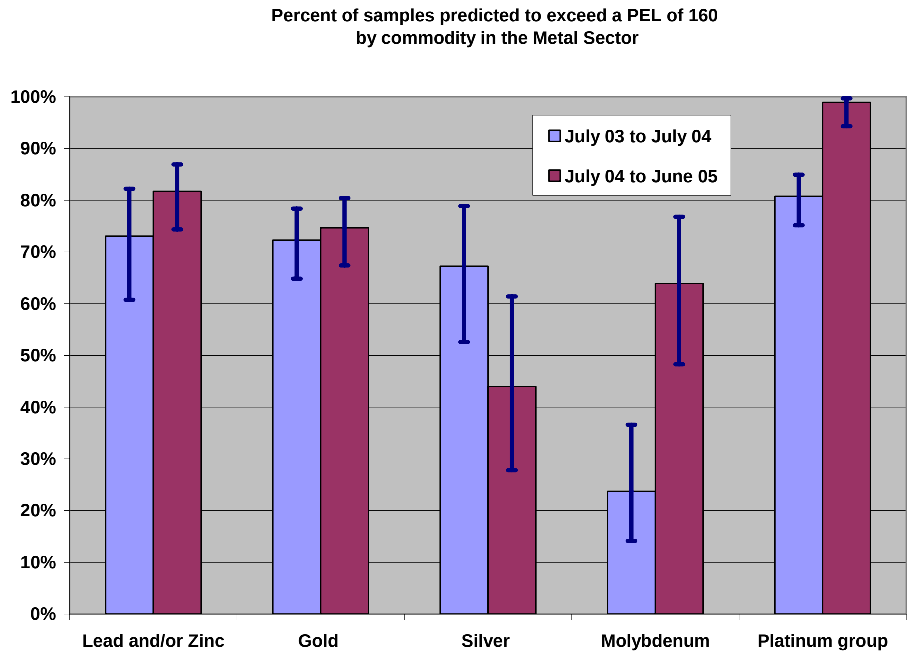

Figure 3

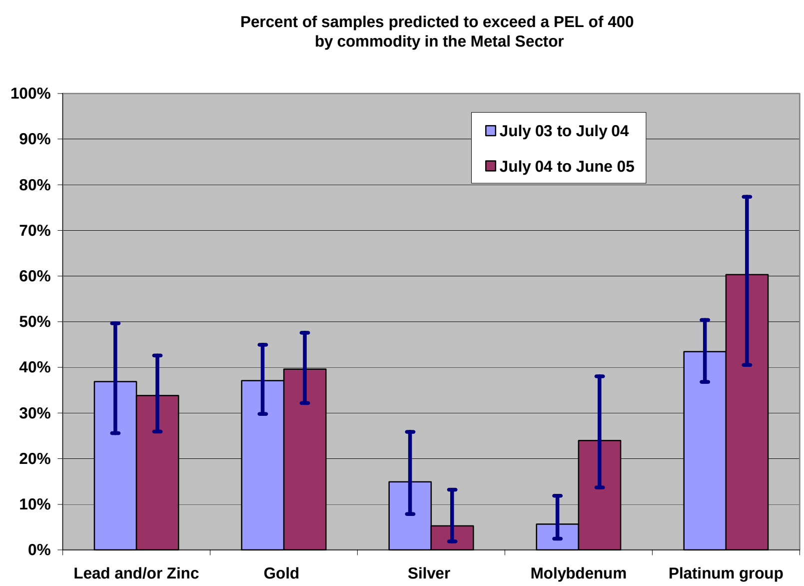

Figure 4

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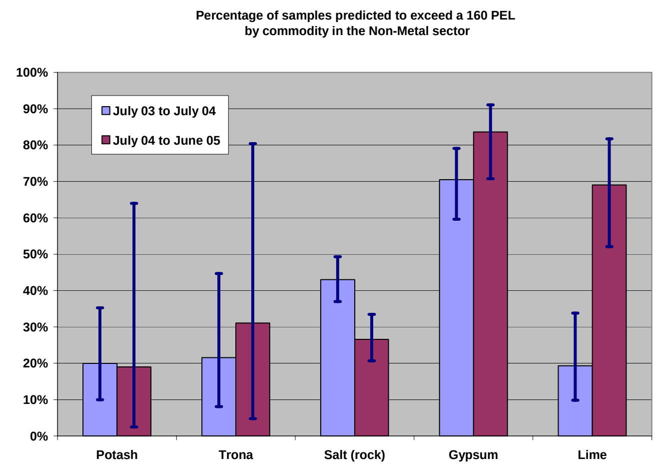

Figure 6

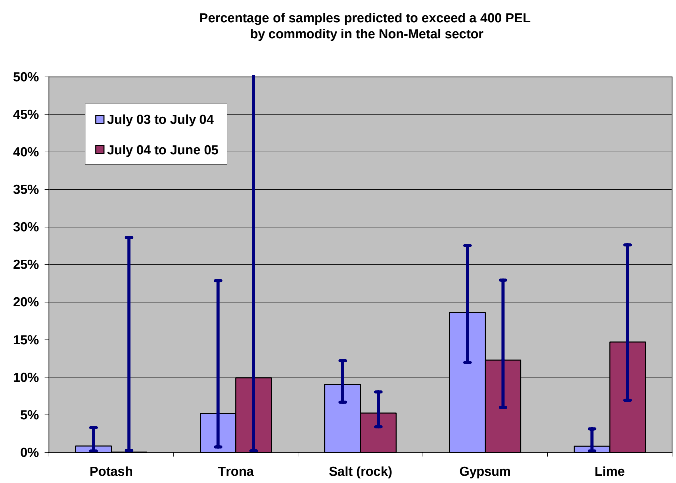

Figure 7

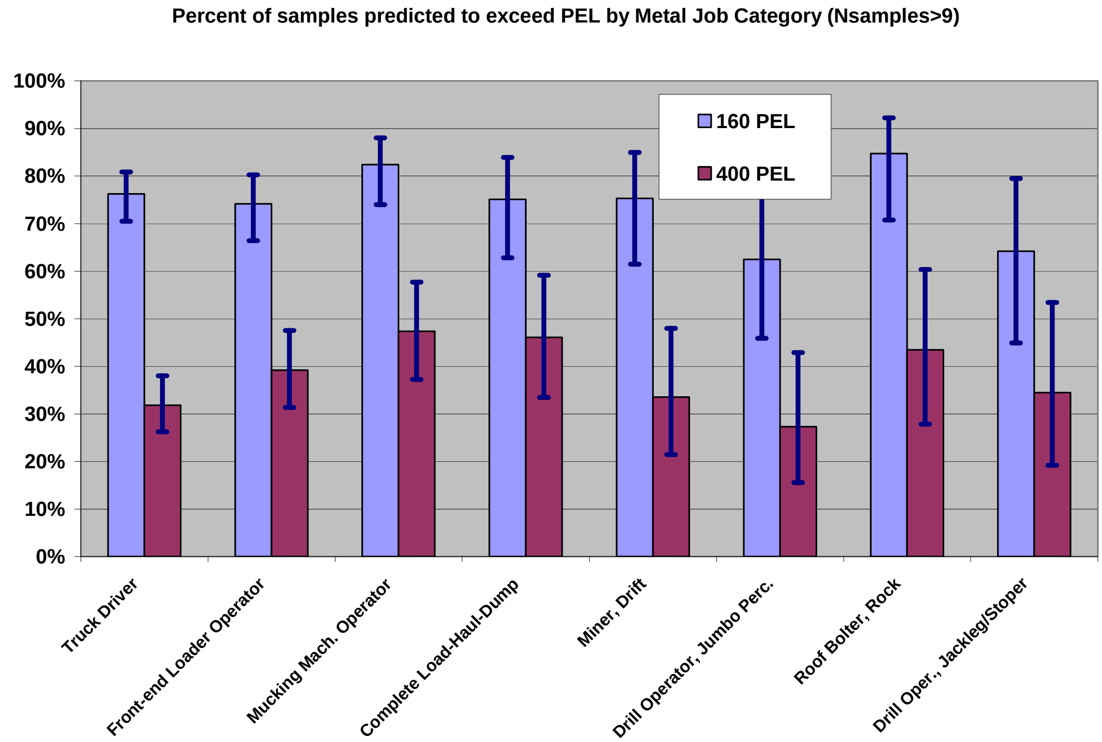

Figure 8

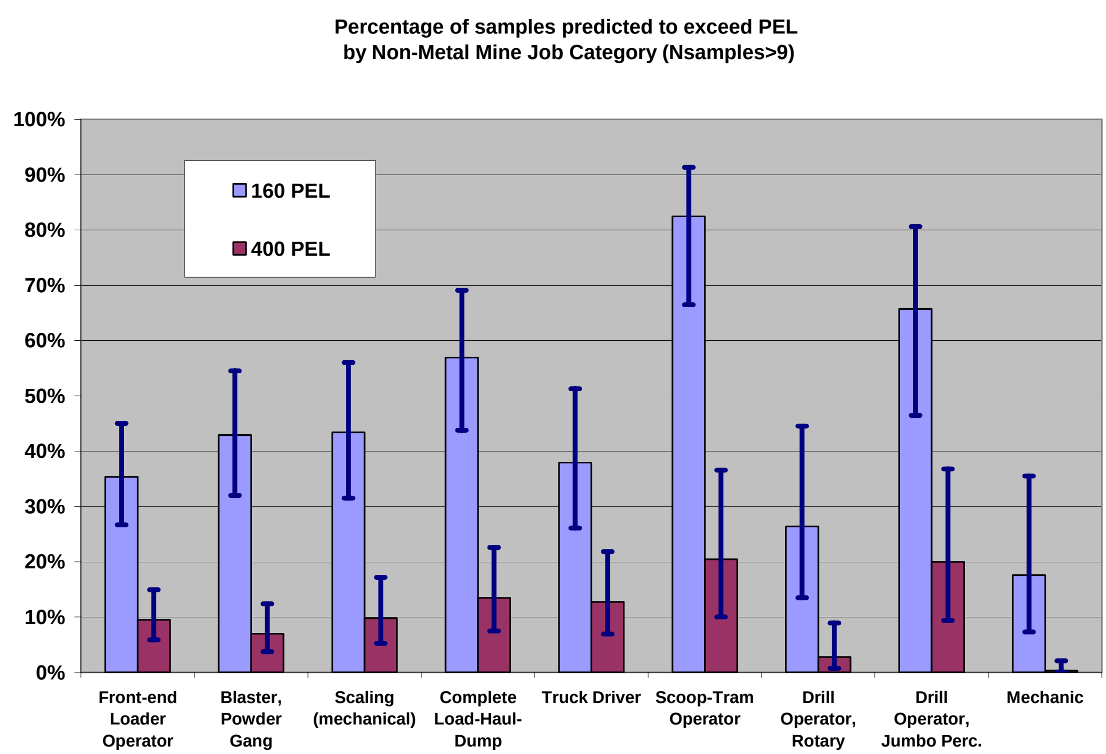

Figure 9

Percentage of samples predicted to exceed PEL
by Stone Job Category (Nsamples>9)

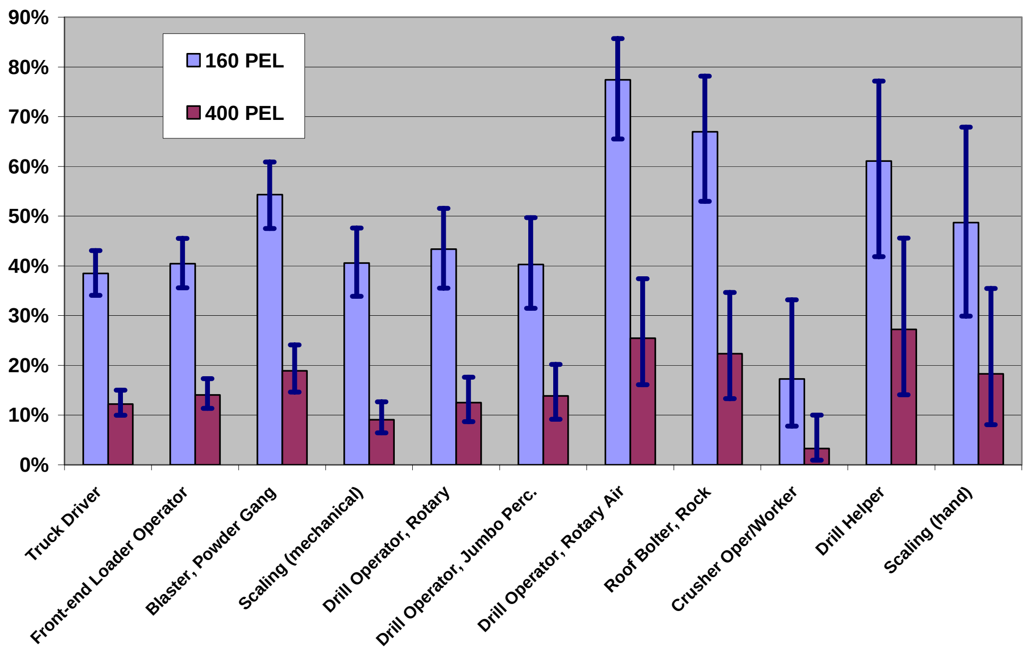

Figure 10

Percentage of samples predicted to exceed a PEL of 160 by sector and job category

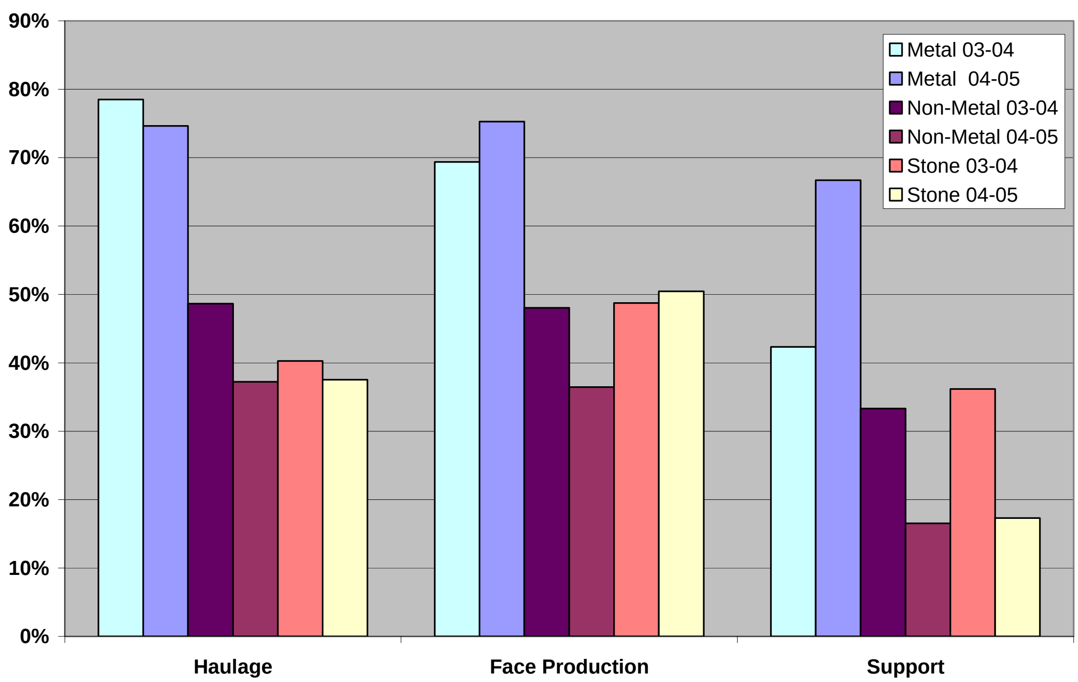

Figure 11

Predicting the current level of exposure:

A further use of the exceedance test method is to calculate what occupational exposure limit would produce a certain exceedance target at the 95% UCL. The current occupational exposure across a range of potential exceedance fractions is represented in figures 12, 13 and 14.

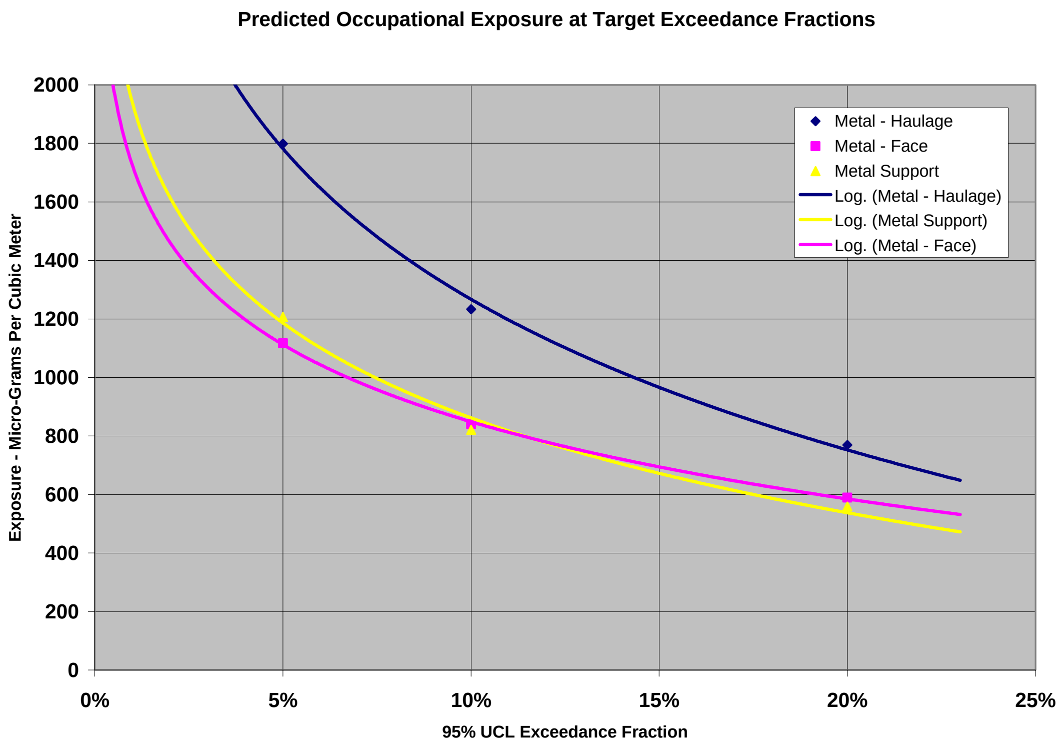

Figure 12: Metal

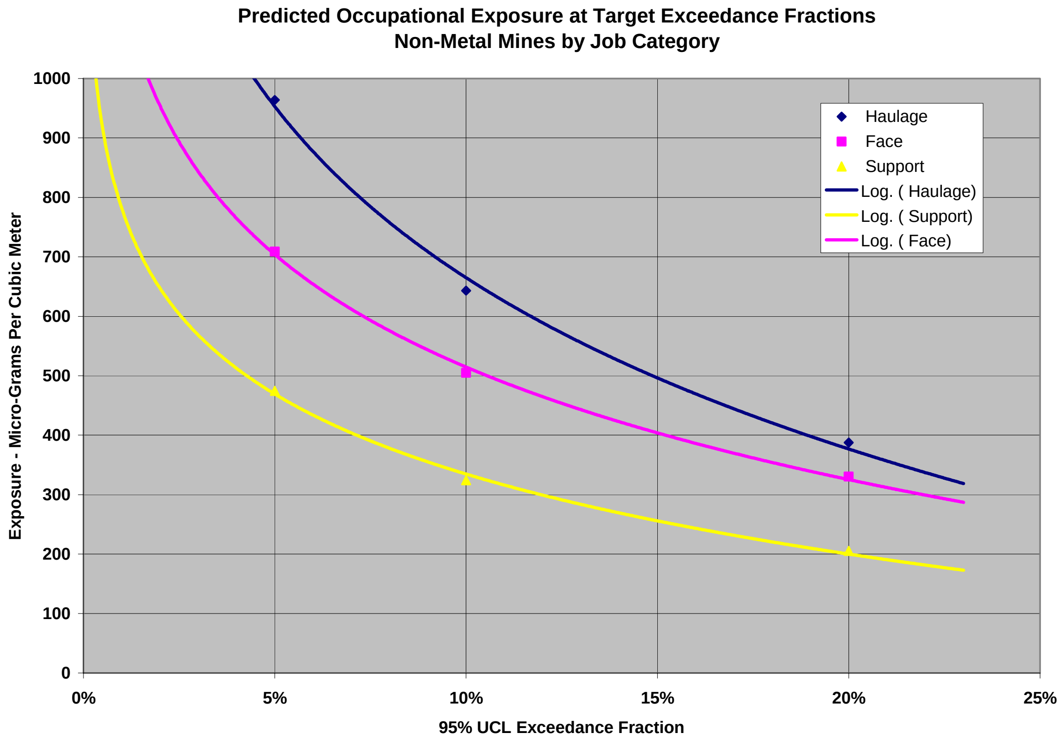

Figure 13

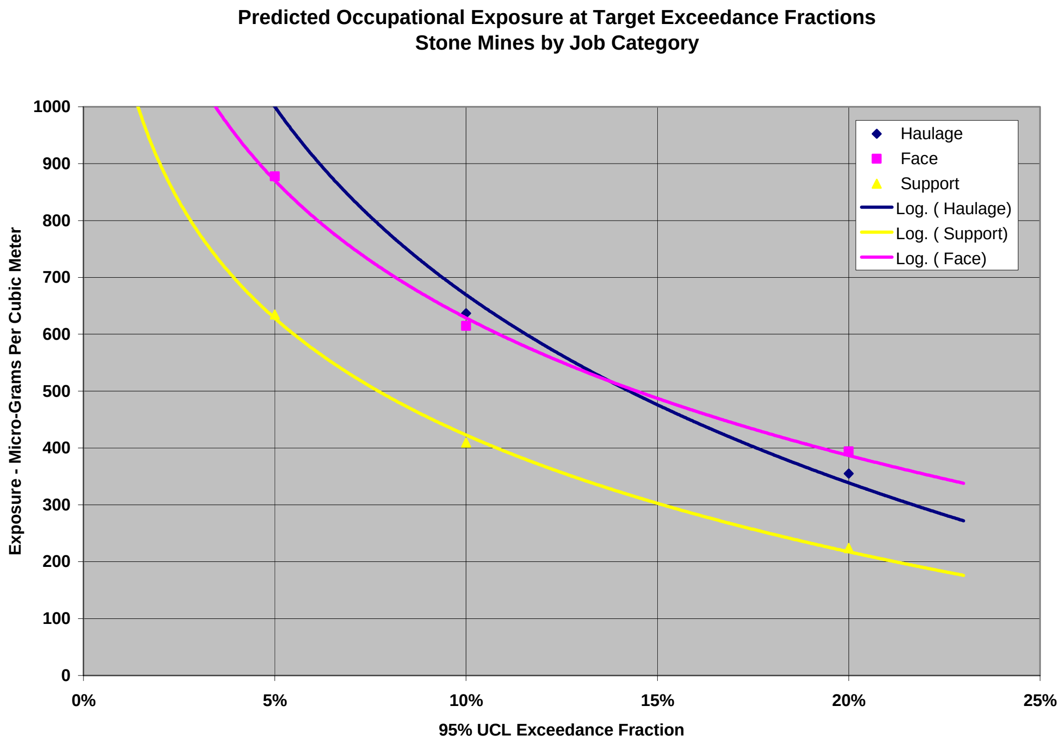

Figure 14

References

Hewett, P and Ganser GH (1997). Simple procedures for calculating confidence intervals around the sample mean and exceedance fraction derived from lognormally distributed data. Appl Occup Envion Hyg 12(2): 132-142.

Hornung RW and Reed LD (1990). Estimation of average concentration in the presence of nondetectable values. Appl Occup Envion Hyg 5(1): 46-51.