Silica and other exposures

KS Creely et al. HSE Research Report RR460 (2006).
Trends in Inhalation Exposure Mid 1980's till Present.

The report provides detailed analysis of actual exposures in industry from the mid 1980s to the early 2000s. The report focuses on silica, toluene and wood dust and provides useful information derived from a database of other exposures. Overall there are clear signs that occupational exposures are below the acceptable standards and are reducing, the main exception being exposure to flour dust.

Exposure via inhalation is the main mechanism leading to liability risk for occupational disease [excluding noise] and is the main focus of HSE occupational hygiene standards and inspection activity. Industry has responded positively to the Official exposure standards but has this lead to reduced exposures? If so, by how much?

This report analyses information obtained by HSE inspectors since 1986 and by researchers with an interest in particular work sites. Interest focussed on exposure to crystalline silica, toluene and wood dust but many other exposures are analysed in this report. Trends in exposures would indicate those industries that were making improvements and mean exposures would help identify work sites where it could be argued that protection was sub-standard.

The National Exposure DataBase (NEDB) is managed by HSE and was set up in 1986. Since then 80,000 exposure samples have been analysed and recorded. The most frequently occurring samples were for quartz, total dust, toluene and styrene. Data was also taken from the Institute of Occupational Medicine (IOM) research projects database which began in 1984, covering respirable dust and quartz in quarries. Rubber dust and fume data were obtained from an EC project (known as ExAsRub) which has been in operation since 1965. IOM has been providing an exposure assessment consultancy service for many years, providing further data on individual companies. This source provided additional information on wood dust, toluene, flour dust and quarry dust. All sources were subject to potential bias e.g. why were HSE inspecting a site, why did a company volunteer to help the EC project, why was IOM approached to provide exposure assessment services?

Results

The following tables provide an analysis of exposures to quarry dust and crystalline silica, averaged over the entire period of data collection. Information on trends is presented graphically.

Readers are referred to the original source for data on toluene (highest exposures in painting and paint manufacture), flour dust (highest exposures in cleaning work in bakeries), wood dust, Rubber dust (highest exposures in "compounding and mixing" and in cleaning work), rubber fume (highest exposures in compounding and mixing).

A reminder:

Arithmetic Mean is given by the sum of all measurements divided by the number of measurements (usually referred to as the average).

Geometric Mean (GM) is given by taking the nth root of the product of n numbers, and is always smaller than or equal to the arithmetic mean. GM is the more useful measurement of mean when the effect of interest is multiplicative, such as compound risk. In assessing the performance of an individual site, a judge would, in our view, probably prefer to make a comparison with the arithmetic mean.

Geometric Standard Deviation (GSD) measures the range of values around the GM, within which, 65% of measurements should come.

Workplace Exposure Limit (WEL) is the maximum permitted exposure measured over either an 8 hour or 15 minute reference period.

Crystalline silica

Data taken from extensive studies of quarrying work.

During most of the observation period the occupational exposure standard [8-hour time weighted average] for general respirable dust was 5 mgm^{-3} [now 4 mgm^{-3}] and for respirable crystalline silica 0.3 mgm^{-3} [under review, likely to become 0.1 mgm^{-3}].

Table 13: Respirable dust exposure (mg m^{-3}) by occupation

Occupation	N	AM	GM	GSD	Min	Max
Drillers	73	1.90	1.12	2.80	0.20	12.00
Drivers/mobile plant operators	1208	0.77	0.48	2.51	<0.01	54.90
Crushers and screens	578	2.48	1.11	2.94	<0.01	367.29
Ancillary plant operators	280	3.51	0.84	3.01	<0.01	554.00
Baggers and fillers	71	1.49	0.75	2.99	0.04	14.53
Weighbridge attendants	111	0.49	0.29	2.82	<0.01	4.79
Maintenance workers	254	2.18	0.81	2.74	0.03	240.20
Supervisors and miscellaneous	362	0.84	0.49	2.61	<0.01	32.64

N = number of measurements
AM = Arithmetic mean
GM = Geometric mean
GSD = Geometric standard deviation
Min: Minimum exposure
Max: Maximum exposure

Exposures were measured by personal monitoring. Actual exposures to individuals would be reduced by personal protective equipment. The results indicate compliance with occupational exposure standards, however, there is clear evidence that peak exposures can be 100 times the general exposure level and some research shows that peak exposures can present a disproportionate risk.

Table 14: Respirable quartz exposure (mg m^{-3}) by occupation for quarries with respirable dust levels containing on average more than 10% quartz

Group job	n	%<LoD	AM	GM	GSD	Min	Max
Drillers	35	9	0.32	0.11	4.71	<0.01	3.30
Drivers/mobile plant operators	452	20	0.08	0.04	3.42	<0.01	0.72
Crushers and screens	197	3	0.32	0.17	3.55	<0.01	3.40
Ancillary plant operators	82	9	0.13	0.06	3.64	<0.01	0.83
Baggers and fillers	10	0	0.17	0.12	2.57	0.03	0.57
Weighbridge attendants	45	42	0.06	0.02	3.44	<0.01	0.56
Maintenance workers	74	15	0.20	0.06	4.44	<0.01	4.50
Supervisors and miscellaneous	125	18	0.09	0.05	3.27	<0.01	0.56

N = number of measurements
%<LoD = Percentage of measurements with results below the limit of detection
AM = Arithmetic mean
GM = Geometric mean
GSD = Geometric standard deviation
Min: Minimum exposure
Max: Maximum exposure

Exposures to respirable crystalline silica at a rate of 0.3 mg m^{-3} for a working lifetime would present a significant (>15%) risk of detectable silicosis. Risk is magnified by short spells of high exposures. In this context, high exposures were observed for drillers, crushers and maintenance workers, all of whom should have been wearing face masks with at least a factor of 10 protection.

Where the level of exposure was below the level of detection this provides some evidence that exposure controls were in place and were effective.

The following graphs show how exposure has varied since the mid 1980's. It would seem that a WEL for respirable crystalline silica of 0.1 mgm^{-3} was not, by default, a practicable option for the entire workforce up to 1996. Exposures for crushers, drillers and ancillary plant operators were clearly in excess of this level.

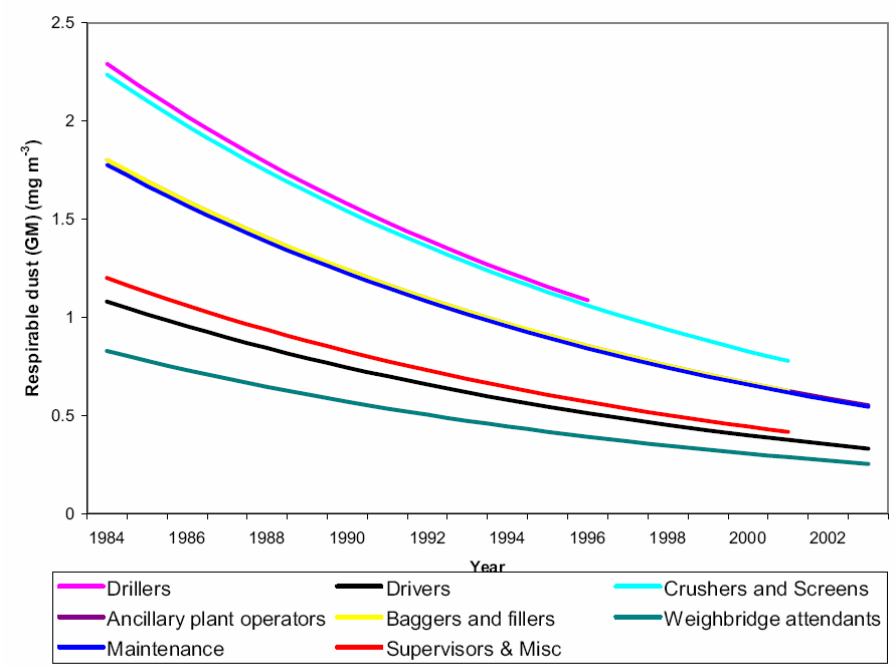

Figure 11: Temporal trends in respirable dust exposure by occupation

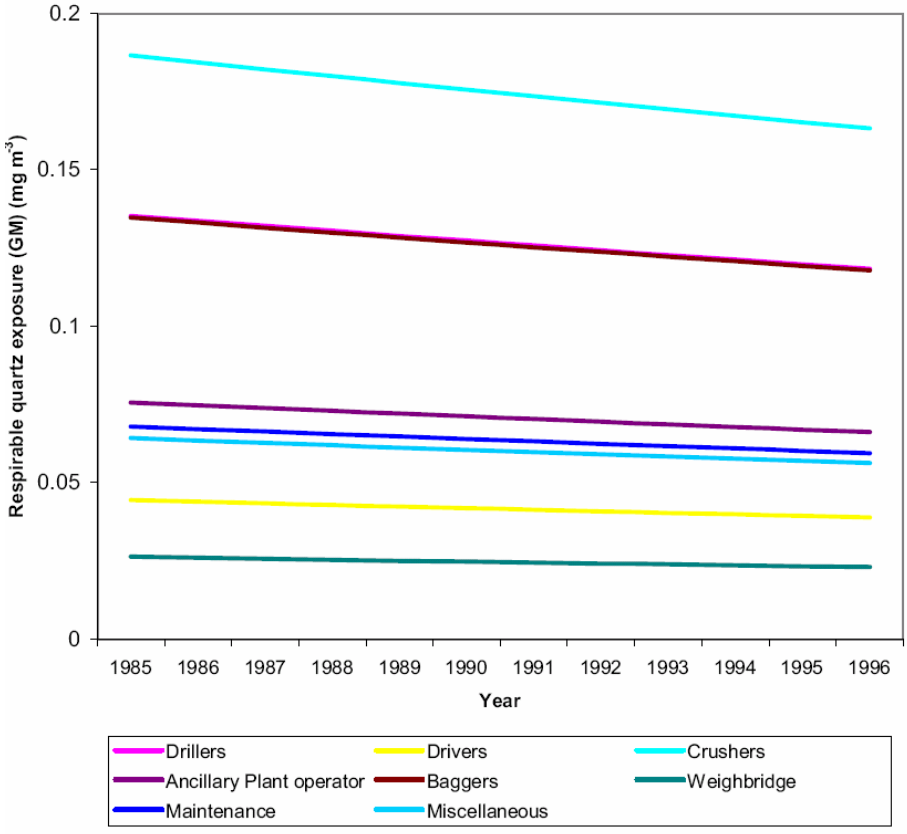

Figure 12: Trends over time in respirable quartz exposure by occupation

Exposure reductions provide evidence of continued effort to protect health, assuming that geological conditions remained stable over the period of observation.

Comment

Data such as this could be used for benchmarking purposes and for estimation of risk.

Flour dust was the only exposure which failed to decrease over the study period. The most dramatic reductions were in exposures to “fibres”.

The report summarise observed exposures recorded in the course of academic studies with respect to: Beryllium, Lead, Carbon Disulphide, Trichloroethylene, perchloroethylene, benzene, styrene, acetone, dichloromethane, xylene, hexavalent chromium, welding fume, wood dust, silica, bitumen, mercury, and refractory ceramic fibres.