Worker exposure to silica dust in South African non-mining industries in Gauteng: An exploratory study

Norman N. Khoza[1], Tanya Grové[1] and Petrus C. Schutte[1]

[1]Council for Scientific and Industrial Research

Corresponding author:

Norman N. Khoza,

CSIR: Centre for Mining Innovation,

P.O. Box 91230,

Auckland Park.

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Tel: 011 358 0078 Fax: 011 482 3267

E-mail: NKhoza@csir.co.za

Membership:

All authors are members of the South African Institute of Occupational Hygiene (SAIOH)

Abstract

Background: Silicosis has long been associated with non-mining industries; however, there has been a paucity of studies regarding silica dust exposure in these industries. Silicosis is an incurable and non-reversible disease, but is highly preventable. This study aimed to quantify exposure levels of workers to silica dust per industry.

The objective: To determine workers' exposure to silica dust in non-mining industries.

Methods: An exploratory study of six non-mining industries was conducted, with 306 breathing-zone personal samples measured using MDHS14/3.

Results and discussion: The silica dust exposure percentages that exceeded the South African Occupational Exposure Limit were foundries 64.8%, sandstone factories 56%, ceramics/potteries 53%, refractories 35%, and sandblasting 2.4%. The overall maximum and minimum exposures were 5.772 and 0.009 mg/m^3, respectively.

Conclusion: Workers are potentially at high risk of contracting silicosis and other diseases associated with respirable silica dust. Dust control and monitoring were inadequate in the industries visited. It is recommended that an in-depth study be conducted and that airborne dust-control programmes be implemented.

Key words: non-mining industries, silica dust, respirable crystalline silica dust, silicosis, South Africa

1. Introduction

Silicosis, a type of pneumoconiosis caused by exposure to respirable crystalline silica dust, is an incurable and non-reversible disease, but it is highly preventable.[1] It is one of the most important health problems in the world, because of its potential to cause physical disability.[2] Silicosis has a long latency period and can occur ten to 20 years after exposure has stopped.[3] However, high exposure to silica dust is associated with short latency and fast progression of the disease.[1-3] The extent of the disease depends on the nature and concentration of the dust, duration of exposure, and individual's susceptibility to the disease.[2,5] The global approach to the elimination of silicosis is focused on the control of exposure to silica dust.[2,5]

Respirable crystalline silica (quartz) is a common mineral in the earth's crust, abundant in most rocks, sands and soils and extremely resistant to weathering.[6, 7, 8] The International Agency for Research on Cancer (IARC) [9] links the potential exposure to quartz for workers in many industries directly to the extensive natural occurrence of quartz in sand, stone and soil and also to the wide uses of materials that contain quartz. Exposures occur during disturbance of silica and the use of products containing silica.[3, 6, 7, 9] Potentially hazardous exposures can occur when the surface of the earth is disturbed in any manner (mining, farming or construction) or when sand, stones or rocks are drilled, moved, crushed or processed. For example, a study on Tanzanian stone crushers found that the mean area of respirable dust was 1.2 mg/m³.[10]

In terms of global exposure trends 12% of foundry workers in the USA with 30 years or more of work service had chest radiographs consistent with silicosis.[11] In the USA, from 1985 to 1990, about 11% of the workplace deaths were caused by silicosis, where silicosis was identified on the death certificates.[12, 13] In 2003 about 3 030 foundry workers were reported to be exposed to silica dust and at risk of developing silicosis in Vietnam.[14]

Inadequate dust control and high disease rates in traditional "silica industries" in South Africa cause a serious silicosis problem.[15, 16] The elimination of silicosis is an important public health issue for South Africa because of the strong association between silicosis and TB, combined with the HIV epidemic.[16, 17] Silicosis is common in industrial workers and gold miners, with an attendant high TB risk.[17] Silicosis has long been associated with non-mining industries in other countries; however, there has been a paucity of studies regarding silica dust exposure in South Africa. The South African Department of Labour's (DoL) endeavour to cap the scourge of silicosis resulted in the introduction of the National Programme for the Elimination of Silicosis in 2004,[15] the reduction of South Africa's Occupational Exposure Limit (RSA-OEL) for silica dust from 0.4 mg/m³ to 0.1 mg/m³ in 2008,[18], and the commissioning of a research project to establish the extent of workers' exposure to silica dust in non-mining. This report contains the results of phase two of this project. A strategic plan was developed for 2010 to 2015 to reduce 20% of employees' exposure to silica dust by establishing provincial silicosis working groups, conducting awareness-raising road shows on the dangers of silica dust, assisting companies to develop silicosis-prevention programmes, and conducting regular inspections and enforcing compliance.[19]

The main aim of the study was to quantify the workers' exposure levels to silica dust in their respective occupations, as there is a paucity of such information for non-mining industries in South Africa.

2. Methodology

An exploratory study was conducted in six non-mining industries (foundry, sandstone, sandblasting, ceramics/pottery, construction and refractory) in Gauteng province of South Africa. Two companies from each industry were conveniently selected from a list of non-mining industries obtained from the DoL by phone calls to ask their permission to participate in the study. Companies that did not make use of silica sand for blasting in sandblasting or exposed to silica dust in construction were excluded. The "maximum risk employees", who were identified after discussion with the supervisor or owner of each company, were sampled. Data was collected in May, June and July 2010. Permission to publish the study was obtained from the Department of Labour, who commissioned the study.

Respirable dust was measured using gravimetric sampling pumps, with Higgens-Dewell cyclones, pre-calibrated at a flow rate of 2.2 l/min and post-calibrated. Measurements were taken in accordance with the Health and Safety Executive laboratory method for the determination of hazardous substances: "MDHS 14/3: General methods for sampling and gravimetric analysis of respirable and inhalable dust". Analysis of respirable quartz concentration was undertaken using "MDHS 101: Crystalline silica in respirable airborne dusts: Direct-on-filter analysis by infrared spectroscopy and X-ray diffraction". Analysis took place at the CSIR SANAS-accredited (ISO 17025) laboratory for both these methods.[20, 21]

A total of 306 breathing zone personal samples were measured for approximately eight hours in duration (mean 507 min) over the course of three consecutive days for individual occupations. Data was analysed by SPSS version 18 and M Excel® spreadsheet. The results are discussed as maximum, minimum, mean, median exposure, and percentage equal to or greater than the RSA-OEL.

3. Results

Three-hundred-and-six (*n*=306) personal sampling measurements taken over a period of approximately eight hours (mean 507 minutes, maximum 920 minutes, minimum 268 minutes and median 503 minutes) were collected in six non-mining industries. The distribution of these samples across the six industries is shown in Table 7.

3.1 Occupational exposure to respirable silica dust and respirable dust in two foundries

The overall mean, median and maximum time-weighted average (TWA) concentrations of respirable silica dust were 0.170 mg/m^3, 0.662 mg/m^3 and 0.154 mg/m^3, respectively. Of all occupations measured 64.8% were exposed to a silica dust level of above the RSA-OEL of 0.1 mg/m^3.[18] Occupations with the highest exposure were casting operator and grinder, with the minimum, mean, median and maximum levels of exposure for both occupations exceeding the RSA-OEL (Table 1).

The overall mean, median and maximum TWA respirable dust exposure levels for all occupations were 1.422 mg/m^3, 1.139 mg/m^3 and 9.294 mg/m^3, respectively. Only 4% of the overall occupations had exposure to respirable dust of above the RSA-OEL[22] of 5 mg/m^3 (Table 1).

3.2 Occupational exposure to respirable silica dust and respirable dust in two sandstone companies

The overall mean, median and maximum TWA respirable silica dust levels from sandstone companies were 0.656 mg/m^3, 0.106 mg/m^3 and 5.772 mg/m^3, respectively. Of the overall measured occupations, 56% were exposed to respirable silica dust levels of above the RSA-OEL. All the stone carvers were over-exposed to silica dust at above the RSA-OEL, with minimum, maximum, mean and median levels at 2.337 mg/m^3, 5.772 mg/m^3, 3.638 mg/m^3 and 3.247 mg/m^3, respectively. The majority of stone polishers, stone masons, forklift drivers and packers had maximum measurements that exceeded the RSA-OEL.[18]

Only 9% of the overall occupations were exposed to respirable dust levels above the RSA-OEL. The overall mean, median and maximum TWA respirable dust concentrations were 1.857 mg/m^3, 0.58 mg/m^3 and 26.080 mg/m^3, respectively (Table 2).

3.3 Occupational exposure to respirable silica dust and respirable dust in two sandblasting companies

The overall mean, median and maximum TWA respirable silica dust concentrations from the sandblasting companies were 0.022 mg/m³, 0.012 mg/m³ and 0.119 mg/m³, respectively. Only 2.4% of all occupations measured were exposed to silica dust at above the RSA-OEL and only the blaster had an exposure of above the RSA-OEL.[18] The total occupation mean, median and maximum TWA respirable dust concentrations in sandblasting were 1.471 mg/m³, 0.527 mg/m³ and 10.835 mg/m³, respectively. Only 7% of dust measured exceeded the respirable dust RSA-OEL[18, 22] (Table 3).

3.4 Occupational exposure to respirable silica dust and respirable dust in two construction companies

The entire overall mean, median and maximum TWA occupational exposure concentrations measured in the construction industry companies sampled were below the OEL for both respirable silica dust and respirable dust (Table 4).

3.5 Occupational exposure to respirable silica dust and respirable dust in two ceramic/pottery industries

The overall occupational mean, median and maximum TWA respirable silica dust exposures in the ceramic/pottery industry were 0.269 mg/m³, 0.105 mg/m³ and 2.900 mg/m³, respectively. Of the occupations measured, 53% were exposed to silica dust at above the RSA-OEL. [18] The clay worker and dispatch clerk occupations were exposed to silica dust where mean, median and maximum levels exceeded the RSA-OEL of silica dust. Only 2% of occupations exposed to respirable dust were exposed to levels above the RSA-OEL[22] for respirable dust (Table 5).

3.6 Occupational exposure to respirable silica dust and respirable dust in two refractories

The overall mean, median and maximum TWA respirable silica dust concentrations for refractories were 0.084 mg/m³, 0.042 mg/m³ and 0.355 mg/m³, respectively. A total of 35% of occupations measured exceeded the RSA-OEL for silica dust. [18] The chemical batcher, operator bagger, chemical additioner and control room operator had median, mean and maximum concentrations of above the RSA-OEL.

The overall mean and maximum TWA respirable dust concentrations for refractories were 3.483 mg/m³ and 15.210 mg/m³, respectively. Of the respirable dust concentrations measured, 28% were above the RSA-OEL (Table 6). They were using refractory material to manufacture breaks.

4. Discussion

4.1 Foundries

Occupational exposures to respirable silica dust in the foundries measured were mainly from the silica sand used in making moulds and cores, and during sand preparations, knock-out, grinding or blasting. The mean TWA respirable silica dust exposures were the highest in the moulder, shake-out operator, grinder, and sand mixing operator, where the exposures were two times higher than the RSA-OEL[18]; and exposures were high in the casting operator, closer and furnace operator (Table 1). The results were similar to the results of studies done in Korea and USA where they reported almost the same occupations but differed in terms of the order of the highest exposed occupations.[23, 24]

A total of 4% and 64.8% (n=54) of occupations overall were exposed to respirable dust and silica dust at above the RSA-OEL[18, 22] respectively. This high exposure could well be attributed to poor dust control and lack of awareness of the dangers and effects of occupational dust, which although not specifically studied were observed during sampling.[15,16] However, the results were lower than the study done in USA where they found that 40.6% of samples exceeded OSHA TWA 0.1 mg/m³ of respirable silica dust as a point of reference.[23]

4.2 Sandstone companies

Occupational exposure to respirable silica dust in sandstone operations emanates from cutting and carving stones that contain 8% to 99% silica content.[25]

Of the samples measured (n=54) for respirable silica dust, 56% had exposures above the RSA-OEL and according to a study done in a similar setting, this places workers at a higher risk of contracting silicosis.[25] The results were similar to a study done in the same industry which reported 5 and 48 times the RSA-OEL of 0.1 mg/m³.[25] A worker was observed using compressed air to blow dust from his clothes; this could be attributed to poor awareness of the dangers of occupational dust. The wet method used to control dust in both companies was ineffective as dust was visibly seen rising into the atmosphere.

4.3 Sandblasting companies

Occupational exposure to respirable silica dust in sandblasting arises from the silica sand used for abrasive sand blasting and sometimes from blasted material if made from dust that contains silica content. The process involves forcefully projecting a stream of silica sand particles onto a surface. Only a sand blasting operator was exposed to TWA total respirable dust with a mean of 2.433 mg/m³. The overall mean TWA respirable silica dust level was 0.119 mg/m³ (Table 3). This was far lower than what is reported in other countries.[26] This could be due to the fact that one company was operating in an open space, where natural ventilation diluted the dust, and there was occasional use of steel grit and glass beads.

Only 2.4% of the overall occupations measured (n=41) were exposed to respirable silica dust above the RSA-OEL.[18] Approximately 7% of all measured occupations were exposed to total respirable dust at above the RSA-OEL of 5 mg/m³.[22] No significant exposure was found in this industry; however, this cannot be generalised to all sandblasting companies in the country, because of the companies measured, one was operating in an open space and the other was using steel grit, glass beads and silica sand most of the time during sampling instead of silica sand.

4.4 Construction companies

There were no significant worker exposures to respirable dust or silica dust in the construction companies sampled. This could be due to the fact that measurements were taken in two construction warehouses in an open space with natural ventilation. Workers were erecting columns and foundations at the time of sampling; had the measurements been taken during the initial earth-moving stage the exposure could have been different. This study did not include road, tunnel, earth-moving, blasting, and paving activities, where exposure is reported to be high (Table 4). The exclusion of the above was due to time constraints as companies involved refused to take part in the study. It is therefore recommended that an extensive study be done in this industry to evaluate the true extent of silica dust exposure, as this is the one of the major industries reported in literature.

4.5 Ceramics/potteries

Handling clay or sand that contains silica is the main source of worker exposure to respirable silica in the ceramics/pottery working environment. Occupations with the highest exposure levels were the dispatch clerk, clay worker and glaze worker, and occupations with high levels of exposure were the casting worker, mould worker, and forklift operator.

Of the overall occupations sampled, 53% were exposed to respirable silica dust at levels of above the RSA-OEL,[18] and 2% were exposed to total respirable dust at levels of above the RSA-OEL[22] (Table 5). Workers were overexposed to silica dust, mainly because they were working in enclosed factories without natural or artificial ventilation in place. There were no mechanical ventilation systems observed during sampling and while employees had FFP2 respiratory protective equipment, these were not frequently used. Poor dust control was probably the main instigator of the above mentioned results, as was previously observed and predicted in a study done in similar and different settings.[13,15]

4.6 Refractories

Workers were overexposed to silica dust in the refractories. Of the overall occupations measured, 35% were exposed to silica dust above RSA-OEL.[18] The refractories had extraction fans installed in control rooms and other strategic areas, but seemingly that was not enough to reduce exposure levels. Occupations with high exposure levels were the operator bagger, chemical batcher, operator weigh larry, chemical additioner, packer and control room operator, and operator shuttle conveyer (Table 6). This is similar to a study done in Indian refractories which found the presence of silica dust in excess of the threshold limit values and the presence of silicosis and other silica-associated abnormalities in the workers.[27]

5. Conclusions, limitations and recommendations

This study has clearly shown that some workers were overexposed to both respirable dust and silica dust. Respirable silica dust exposure percentages that exceeded the RSA-OEL[18] of 0.1 mg/m³ were found in foundries (64.8%), sandstone factories (56%), ceramics/potteries (53%), refractories (35%), and sandblasting (2.4%). These findings accord with an earlier study done in southern Africa.[6] Workers in these industries are potentially at high risk of contracting silicosis, silico-tuberculosis, lung cancer and other occupational respiratory diseases associated with exposure to silica dust. This is similar to a previous study of silicosis in non-mining industries, where foundries were found to have the highest cases of silicosis, followed by ceramics, refractories, stone or ore crushing and abrasive blasting companies.[28] Though this is an exploratory study, the findings in most of the non-mining industries has clearly indicated the high level of workers exposure to crystalline silica dust and the urgency needed to address the problem.

Through observation, it was clear that not enough effort has been made to reduce workers' exposure to respirable silica dust in non-mining industries. Inadequate dust control and dust monitoring were prevalent in the non-mining industries. It is, therefore, recommended that silica dust prevention and controls should be the genesis of all silicosis control measures to be implemented in these industries.[29] This can be achieved through improving dust monitoring, application of best methods to reduce and control dust and lastly implementation of hierarchy of control. For reporting purposes the silica exposure compliance tool developed by the Department of Labour should be used for reporting presence of silica dust in workplaces.[18]

The major limitations of this study were that it was an exploratory study with a small sample size that cannot be extrapolated to represent the general population of non-mining industries in South Africa. It used convenience sampling where companies were asked to participate in the study via telephone. Another limitation of the study was that data collected in the warehouse construction company was not reliable. If it was done during road, demolition, earthmoving and tunnel construction it could have given a different picture. However, the study has revealed to some extent the silica dust exposure levels in South African non-mining industries.

It is strongly recommended that an in-depth nationwide study (baseline) be conducted to determine the true extent of silica dust exposures in the non-mining industry in South Africa, to enable the DoL to track progress made by the National Programme for the Elimination of Silicosis. The sandblasting and construction industries had activities that exposed workers to respirable silica dust at lower levels, but further investigations are recommended.

Lessons learned:

1. Results of this exploratory study indicate that certain workers were overexposed to silica dust in South African non-mining industries.
2. Workers in non-mining industries are, therefore, potentially at high risk of developing silicosis and other occupational respiratory diseases associated with exposure to silica dust.
3. Inadequate dust control and monitoring were prevalent in non-mining industries.
4. Approximate averages of 35% of non-mining workers were exposed to silica dust above the RSA-OEL of 0.1 mg/m^3.

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Table 1: Personal respirable dust and silica dust (mg/m³) exposure in foundries

Occupations	n	Maximum		Minimum		Mean/SD		Median		%≥OEL[a]	
		Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Quartz
Sand mixing operator	12	4.571	0.662	0.157	0.032	1.455 ±1.142	0.206 ±0.174	1.245	0.213	00	58
Shake-out operator	4	2.22	0.322	1.207	0.089	1.582 ±0.460	0.243 ±0.109	1.451	0.281	00	75
Shot-blast operator	8	1.994	0.271	0.291	0.056	0.979 ±0.587	0.140 ±0.084	0.808	0.117	00	75
Furnace operator	6	2.448	0.392	0.282	0.023	1.214 ±0.951	0.147 ±0.134	0.971	0.128	00	67
Casting operator	3	1.656	0.228	0.976	0.107	1.364 ±0.350	0.186 ±0.068	1.461	0.223	00	100
Loco sand filler and remover	8	0.297	0.082	0.058	0.01	0.184 ±0.082	0.025 ±0.024	0.175	0.015	00	00
Moulder	4	2.134	0.468	0.358	0.077	1.420 ±0.755	0.271 ±0.180	1.594	0.269	00	75
Grinder	4	9.294	0.309	0.668	0.120	4.664 ±3.838	0.212 ±0.079	4.348	0.210	50	100
Closer	5	3.014	0.261	0.104	0.050	1.597 ±1.209	0.171 ±0.084	1.504	0.184	00	80
Total	**54**	**9.294**	**0.662**	**0.058**	**0.010**	**1.422 ±1.553**	**0.170 ±0.131**	**1.139**	**0.154**	**4**	**64.8**

[a]South African occupational exposure limit for respirable silica dust (0.1mg/m³)[18] and respirable dust (5mg/m³)[22]
SD=Standard deviation

Table 2: Personal respirable dust and silica dust (mg/m³) exposure in sandstone industries

Occupations	n	Maximum		Minimum		Mean/SD		Median		%≥OEL[a]	
		Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Quartz
Sandstone carver	6	26.08	5.772	3.419	2.337	9.527 ±8.359	3.638 ±1.335	7.493	3.427	67	100
Stone mason	3	0.648	0.113	0.473	0.07	0.569 ±0.089	0.095 ±0.022	0.585	0.101	00	67
Saw operator	18	9.265	3.607	0.1	0.024	1.255 ±2.110	0.482 ±0.878	0.538	0.086	6	44
General labourer	6	1.219	0.464	0.11	0.023	0.503 ±0.394	0.159 ±0.172	0.450	0.086	00	50
Polisher	6	3.768	0.735	0.161	0.077	1.292 ±1.292	0.328 ±0.241	0.947	0.312	00	83
Tractor operator	3	0.341	0.066	0.179	0.031	0.276 ±0.085	0.050 ±0.018	0.307	0.053	00	00
Forklift operator	3	0.982	0.204	0.59	0.082	0.840 ±0.217	0.130 ±0.065	0.947	0.105	00	67
Packer	3	0.583	0.191	0.331	0.061	0.497 ±0.144	0.122 ±0.065	0.576	0.115	00	67
Technician	3	0.414	0.046	0.247	0.02	0.343 ±0.086	0.036 ±0.014	0.367	0.043	00	00
Plant manager	3	0.909	0.355	0.34	0.056	0.707 ±0.318	0.233 ±0.157	0.872	0.287	00	00
Total	**54**	**26.080**	**5.772**	**0.100**	**0.020**	**1.857 ±3.942**	**0.656 ±1.247**	**0.58**	**0.106**	**9**	**56**

[a]South African occupational exposure limit for respirable silica dust (0.1mg/m³)[18] and respirable dust (5mg/m³)[22]
SD=Standard deviation

Table 3: Personal respirable dust and silica dust (mg/m³) exposure in sandblasting companies

Occupations	n	Maximum		Minimum		Mean/SD		Median		%≥OEL[a]	
		Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Quartz
General labour	5	1.888	0.037	0.428	0.009	0.929 ±0.666	0.018 ±0.012	0.519	0.011	00	00
Pots worker	4	2.099	0.03	0.145	0.009	0.847 ±0.870	0.018 ±0.010	0.571	0.016	00	00
Blaster	19	10.835	0.119	0.128	0.009	2.433 ±0.833	0.027 ±0.028	0.833	0.013	16	5
Painter and assistant painter	4	1.037	0.045	0.41	0.009	0.603 ±0.294	0.024 ±0.017	0.483	0.021	00	00
Forklift driver	3	1.017	0.035	0.216	0.009	0.530 ±0.428	0.020 ±0.014	0.357	0.015	00	00
Supervisor	3	0.132	0.01	0.06	0.009	0.107 ±0.041	0.009 ±0.001	0.129	0.009	00	00
Maintenance officer	3	1.362	0.036	0.073	0.009	0.574 ±0.691	0.022 ±0.014	0.286	0.020	00	00
Total	**41**	**10.835**	**0.119**	**0.06**	**0.009**	**1.471 ±2.388**	**0.022 ±0.021**	**0.527**	**0.012**	**7**	**2.4**

[a]South African occupational exposure limit for respirable silica dust (0.1mg/m³)[18] and respirable dust (5mg/m³)[22]
SD=Standard deviation

Table 4: Personal respirable dust and silica dust (mg/m³) exposure in construction companies

Occupations	n	Maximum		Minimum		Mean/SD		Median		%≥OEL[a]	
		Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Quartz
General labourer	14	0.333	0.062	0.01	0.009	0.073 ±0.079	0.013 ±0.014	0.064	0.009	00	00
Bobcat operator	2	0.326	0.03	0.233	0.018	0.280 ±0.066	0.024 ±0.008	0.280	0.024	00	00
Concrete hand	14	0.418	0.048	0.039	0.009	0.146 ±0.107	0.021 ±0.014	0.126	0.014	00	00
Carpenter	9	0.488	0.046	0.046	0.009	0.156 ±0.162	0.019 ±0.013	0.064	0.013	00	00
Safety officer	2	0.155	0.015	0.028	0.014	0.092 ±0.090	0.015 ±0.001	0.092	0.015	00	00
Steel fixer	5	0.246	0.041	0.016	0.009	0.142 ±0.089	0.018 ±0.014	0.169	0.011	00	00
Shutter hand	3	0.102	0.021	0.031	0.009	0.074 ±0.038	0.013 ±0.007	0.088	0.010	00	00
Total	**49**	**0.488**	**0.062**	**0.01**	**0.009**	**0.126 ±0.112**	**0.017 ±0.013**	**0.073**	**0.010**	**00**	**00**

[a]South African occupational exposure limit for respirable silica dust (0.1mg/m³)[18] and respirable dust (5mg/m³)[22]
SD=Standard deviation

Table 5: Personal respirable dust and silica dust exposure (mg/m³) in ceramic/pottery industries

Occupations	n	Maximum		Minimum		Mean/SD		Median		%≥OEL[a]	
		Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Quartz
Labourer	6	1.161	0.118	0.107	0.01	0.495 ±0.456	0.054 ±0.045	0.266	0.041	00	17
Clay worker	12	4.789	0.913	0.377	0.054	2.181 ±1.501	0.409 ±0.296	1.717	0.370	00	92
Casting worker	3	1.389	0.479	0.199	0.013	0.616 ±0.670	0.186 ±0.255	0.259	0.066	00	33
Glaze worker	12	3.188	1.513	0.28	0.009	1.083 ±0.935	0.253 ±0.480	0.696	0.070	00	17
Supervisor	6	0.972	0.209	0.103	0.009	0.609 ±0.365	0.098 ±0.078	0.709	0.103	00	67
Mould worker	3	0.832	0.201	0.353	0.057	0.590 ±0.240	0.131 ±0.072	0.585	0.135	00	67
Dispatch clerk	6	10.664	2.900	0.193	0.009	2.720 ±3.955	0.589 ±1.136	1.321	0.186	17	67
Forklift operator	3	0.838	0.144	0.32	0.083	0.627 ±0.272	0.119 ±0.032	0.722	0.129	00	67
Total	**51**	**10.664**	**2.900**	**0.103**	**0.009**	**1.326 ±1.706**	**0.269 ±0.477**	**0.737**	**0.105**	**2**	**53**

[a]South African occupational exposure limit for respirable silica dust (0.1mg/m³)[18] and respirable dust (5mg/m³)[22]
SD=Standard deviation

Table 6: Personal respirable dust and silica dust (mg/m³) exposure in refractory companies

Occupations	n	Maximum		Minimum		Mean/SD		Median		%≥OEL[a]	
		Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Silica dust	Dust	Quartz
Chemical batcher	2	6.876	0.275	1.802	0.053	4.339 ±3.588	0.164 ±0.157	4.339	0.164	50	50
Operator shuttle conveyor	3	5.378	0.162	2.617	0.056	3.664 ±1.497	0.100 ±0.055	2.996	0.083	33	100
Packer	4	10.27	0.215	0.619	0.009	4.981 ±5.040	0.102 ±0.104	4.517	0.093	50	50
Operator bagger	6	11.028	0.355	0.712	0.014	5.575 ±3.430	0.171 ±0.113	5.003	0.168	50	83
Operator weigh larry	3	15.21	0.24	6.68	0.042	10.250 ±4.431	0.152 ±0.101	8.861	0.175	100	67
Forklift driver	6	14.668	0.152	0.429	0.016	3.969 ±5.408	0.077 ±0.053	1.589	0.074	17	33
Chemical additioner	6	11.825	0.276	1.488	0.044	5.085 ±3.902	0.144 ±0.093	4.260	0.126	50	67
Boyd press operator	3	0.787	0.038	0.031	0.01	0.435 ±0.381	0.020 ±0.016	0.487	0.012	00	00
LAEIS press operator	6	1.063	0.04	0.122	0.009	0.670 ±0.337	0.026 ±0.011	0.682	0.026	00	00
Control room operator	6	7.734	0.18	1.7	0.027	3.858 ±2.594	0.102 ±0.064	2.484	0.105	33	50
Berry press operator	9	4.663	0.035	0.081	0.009	1.197 ±1.578	0.012 ±0.009	0.236	0.009	00	00
Crusher operator	3	0.791	0.009	0.16	0.009	0.390 ±0.349	0.009 ±0.000	0.219	0.009	00	00
Total	**57**	**15.210**	**0.355**	**0.031**	**0.009**	**3.483 ±3.773**	**0.084 ±0.086**	**1.928**	**0.042**	**28**	**35**

[a]South African occupational exposure limit for respirable silica dust (0.1mg/m³)[18] and respirable dust (5mg/m³)[22]
SD=Standard deviation

Table 7: Summarised respirable dust and silica dust (mg/m³) exposure in non-mining industries

Non-mining Industries	Respirable Dust (mg/m³)						Respirable Silica Dust (Quartz) (mg/m³)				
	n	Max	Min	Mean/SD	Median	%≥OEL[b]	Max	Min	Mean/SD	Median	%≥OEL[a]
Foundries	54	9.294	0.058	1.422 ±1.553	1.139	**4**	0.662	0.010	0.170 ±0.131	0.154	**64.8**
Sandstone	54	26.080	0.100	1.857 ±3.942	0.58	**9**	5.772	0.020	0.656 ±1.247	0.106	**56**
Sandblasting	41	10.835	0.06	1.471 ±2.388	0.527	**7**	0.119	0.009	0.022 ±0.021	0.012	**2.4**
Construction	49	0.488	0.01	0.126 ±0.112	0.073	**00**	0.062	0.009	0.017 ±0.013	0.010	**00**
Ceramics/Potteries	51	10.664	0.103	1.326 ±1.706	0.737	**2**	2.900	0.009	0.269 ±0.477	0.105	**53**
Refractories	57	15.210	0.031	3.483 ±3.773	1.928	**28**	0.355	0.009	0.084 ±0.086	0.042	**35**

[a] 0.1mg/m³ South African occupational exposure limit for respirable silica dust (quartz) [18]
[b] 5mg/m³ South African occupational exposure limit for respirable dust[22]
SD=Standard deviation

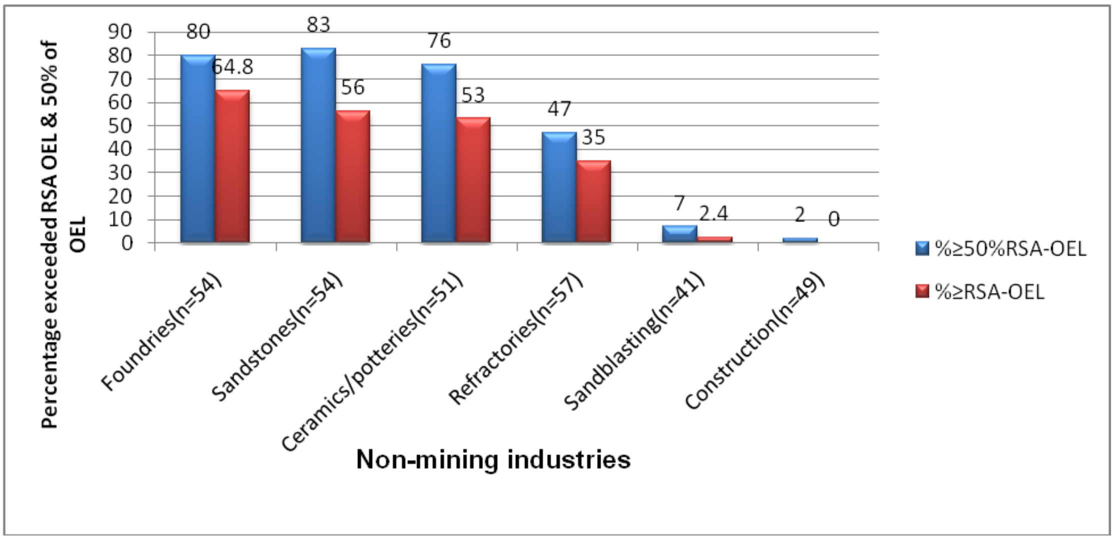

Figure 1: Percentage of silica dust (mg/m³) exposures equal to or above the RSA OEL[18] and 50% of the RSA OEL

Pull quotes

The elimination of silicosis is an important public health issue for South Africa…

The …Department of Labour's … endeavour to cap the scourge of silicosis resulted in the introduction of the National Programme for the Elimination of Silicosis in 2004…

Of all occupations measured [in the foundries] 64.8% were exposed to a silica dust level of above the RSA-OEL of 0.1 mg/m^3.

… 56% [of occupations in sandstone companies] were exposed to respirable silica dust levels of above the RSA-OEL.

Of the overall occupations sampled [in ceramics/ potteries], 53% were exposed to respirable silica dust at levels of above the RSA-OEL