

Controlling dust exposures in the Queensland foundry industry 2009



A report supporting the Occupational Disease Strategy 2007–2010

Introduction

In 2002, on the back of national concern over the increasing monetary and social costs of occupational disease to the Australian community, the federal government released its *National Occupational Health and Safety Strategy 2002–2012* (the Strategy). The Strategy's principal priorities included a reduction in both the high incidence and severity of occupational disease in the workplace, and to develop the capacity of workplaces to manage occupational health and safety (OHS) more effectively.

Workplace Health and Safety Queensland (WHSQ) has recognised this strategy by adopting all of its priorities in the development of the *Occupational Disease Strategy 2007–2010*.

Workplace Health and Safety Queensland recognises there is a wide range of work-related respiratory diseases across many different industries in Queensland. Therefore, it is necessary to consider respiratory disease (and its causative agents) a high priority and to develop programs that specifically target the disease or its causative agents. In this case, the causative agents, respirable dust and respirable crystalline silica, are targeted.

Background

Silica exposure occurs in industries such as quarrying, mining, tunnelling, foundry works, stonemasonry, cement manufacturing, construction, brick and tile manufacture, ceramics and metal polishing.

Silica, as moulding sand, is a fundamental component in the production of metal casting moulds for ductile iron and steel. There is no substitute for this material. Historically, the foundry industry has contributed to the community's occupational silicosis burden. Although this risk has diminished significantly as the number of foundries has decreased and control technology has improved, silica exposure remains an important risk factor for respiratory disease. While silicosis was important historically, respirable crystalline silica (RCS) is now known to cause chronic obstructive lung disease, including chronic bronchitis and emphysema. Chronic exposure to elevated levels of RCS is found to cause cumulative loss of respiratory volume, and poses a risk of silicosis. Those cumulative exposures which are a concern for silicosis are now also a concern for lung cancer.

The effects of altered silica exposures will not be observed until two or possibly three or more decades have elapsed (long latency). Improvements made at any time may not be reflected until decades later. However, widespread reductions in dust and RCS levels will indicate reduced levels of risk. Furthermore, any indication of greater uptake of personal respiratory protective equipment (RPE) will represent a further reduction in risk.

In 2004, the National Occupational Health and Safety Commission (NOHSC) reduced the exposure standard (ES) for RCS from 0.2 mg/m³ (as measured by the British Medical Research Council (BMRC) lung penetration curve) to 0.1 mg/m³ (as an eight-hour time-weighted average measured by the lung penetration curve defined by the International Organisation for Standardisation (ISO)). This corresponded in a real reduction to the exposure standard of around 30 per cent.

This change in standard is automatically adopted in the *Workplace Health and Safety Regulation 2008* (WHS Regulation) Part 16 – Hazardous substances (Regulation 205 – Controlling exposure). Greater control competence is now required in all industries where RCS is encountered. Inspectorate experience over previous decades revealed that the foundry industry was generally not well informed about the RCS exposures of its workers.

The purpose of the intervention

This specific intervention report is the first on sectors involving silica exposure. The intervention targets the foundry industry and its workers exposed to the industry's major causative agents of respiratory disease. The purpose of the intervention is to:

- see if dust levels have been reduced over the last two to three decades
- see if the risk is being controlled more competently
- suggest where attention needs to be paid to further reduce the risk of disease from dust and RCS exposures.

In this study, WHSQ used historical records to compare the past and present performance of the foundry industry.

Information from this intervention program is also available to inform national authorities on future development of the RCS standard. To accompany the program, WHSQ has a designated silica webpage at www.worksafe.qld.gov.au to assist health and safety personnel in silica affected businesses.

Note: Australia's RCS exposure standard is in line with the United Kingdom and the European Occupational Exposure Limit (EU-OEL), but only half as stringent as the US National Institute for Occupational Safety and Health recommendation 0.05 mg/m^3 , and one-fourth as stringent as the current recommendation of 0.025 mg/m^3 from the American Conference of Governmental Industrial Hygienists.

The intervention

The intervention program consisted of four stages:

1. The first involved a presentation to the Australian Foundry Institute to let them know about the coming intervention.
2. The second was a respirable dust and RCS monitoring audit program conducted across 12 foundries located throughout Queensland.
3. The third was to administer a short checklist audit at all the targeted workplaces. This audit attempted to gauge the extent of WHSQ's engagement with its stakeholders on silica. Stakeholders provided responses about their level of awareness of the new RCS standard, the information sources that were used, and the usefulness of the information that was accessed. Also, the workplace compliance was assessed against the administrative requirements of the WHS Regulation and specific activities, such as air monitoring and health surveillance, that are critical to properly controlling risks to RCS. Direct feedback was provided to all but one of the monitored foundries in the form of a comprehensive report with monitoring results and specific recommendations.
4. During the fourth stage, performance of the 2009 target group was assessed against NOHSC's revised 2004 0.1 mg/m^3 RCS standard and against the performance of the same industry during the period 1981–2002, when it operated under the previous 0.2 mg/m^3 respirable quartz standard. This study identified both the extent of current regulatory compliance on RCS for the sector and the trends in RCS exposures and control competence i.e. their demonstrated level of compliance. Individual workplaces were not examined in this report.

The targets of the intervention

This intervention involved reviewing respirable dust and RCS exposures in 12 of about 18 foundries in Queensland, i.e. three small foundries (< 10 workers), two medium-sized ones (10 to 29 workers) and seven large foundries (≥ 30 workers).

The major part of the program's focus was a targeted assessment of worker exposure to respirable dust and RCS of workers who worked in similar foundry work groups, such as moulders, fettlers etc (these are referred to as similarly exposed groups (SEGs)). Day shifts were monitored in all 12 workplaces, with one part-evening shift in one foundry.

By comparing the results with permissible exposures under the WHS Regulation, the industry's performance and control capability were assessed.

The results of the intervention

Results for six different SEGs (refer to Table 1 for all SEG types) are presented graphically in Figures 1–6 for both the earlier and the present 2009 survey. There were 11 workplaces in the early survey and 12 workplaces in 2009.

Observations were made and recorded in all workplaces on the use of controls, particularly the use of particulate RPE for each operator in the different SEGs, and occasional use of ventilation by exhaust systems or fans.

To determine the extent of compliance, recorded exposure is compared with the exposure standard. Foundries surveyed worked from eight to nine and three-quarter hour shifts. To facilitate simple treatment of grouped results in the different SEGs, the exposure standard has been adjusted slightly (and uniformly) downward to account for a slightly longer workshift. A review of the industrial relations working conditions for the 1981–2002 surveys confirmed that foundry workers during that time were most likely to have worked similar hours with regular overtime arrangements. At 9 hours, the shift-adjusted RCS exposure standard is 0.083 mg/m^3 and for 9.5 hours it is 0.076 mg/m^3 . This analysis adopts an average adjusted RCS exposure standard of 0.08 mg/m^3 .

Compliance is based only on the RCS exposures, since there is no specific respirable dust exposure limit applicable for dusts with components of mixed toxicities, and RCS is the most toxic component. RCS content varied from a few per cent to almost 50 per cent depending on the task and circumstance. In each figure, the results are presented as the percentage of each SEG being in one of three groups; $< 0.5 \text{ ES}_{\text{adjusted}}$ (i.e. $< 0.04 \text{ mg/m}^3$), $\geq 0.5 \text{ ES}_{\text{adjusted}}$ up to the $\text{ES}_{\text{adjusted}}$ (i.e. 0.04 mg/m^3 to 0.079 mg/m^3) or $\geq \text{ES}_{\text{adjusted}}$ ($\geq 0.08 \text{ mg/m}^3$). Use of $0.5 \text{ ES}_{\text{adjusted}}$ as a benchmark or action level is based on the advice provided in the *Hazardous Substances Code of Practice 2003*. Where exposure has been measured at or above 0.5 ES , the circumstance of exposure needs to be reviewed.

The bunching of bars to the left hand of each figure is the ideal situation. Poorer performance in any SEG is indicated by bars appearing to the right of each figure (i.e. $\geq \text{ES}_{\text{adjusted}}$).

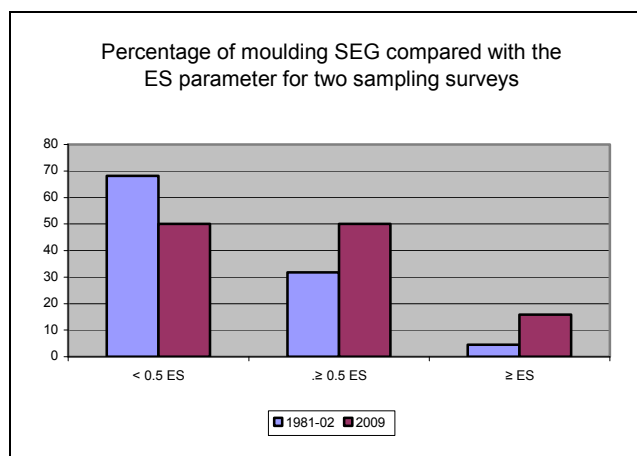


Figure 1: Proportion of moulding SEG exceeding either the 0.5 ES action level or the ES

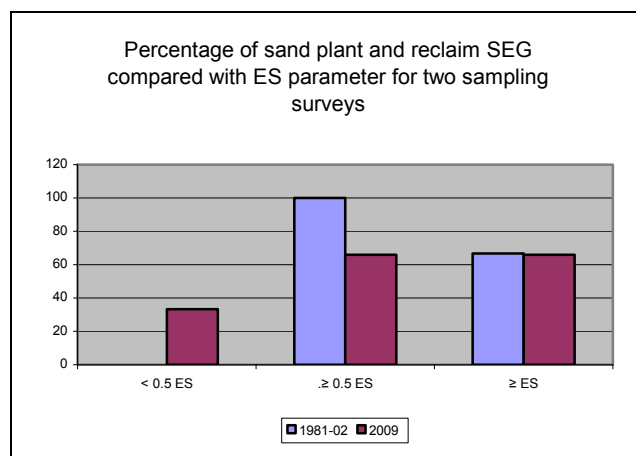


Figure 2: Proportion of each sand plant and reclaim SEG exceeding either the 0.5 ES action level or the ES.

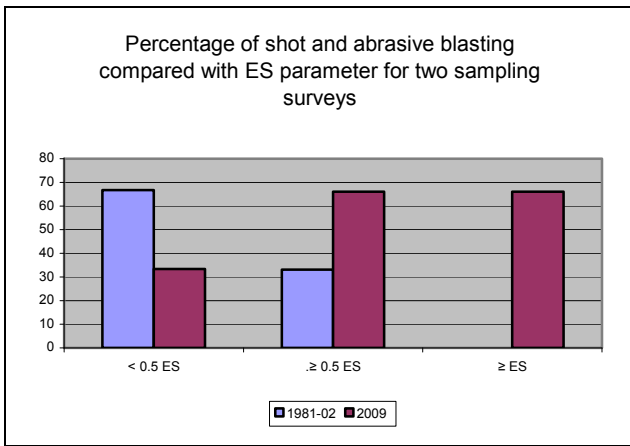


Figure 3: Proportion of shot and abrasive blasting SEG exceeding either the action level or the ES

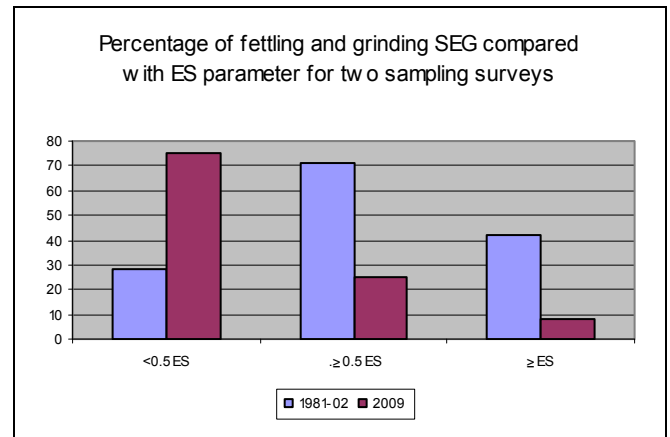


Figure 5: Proportion of fettling and grinding SEG exceeding either the action level or the ES

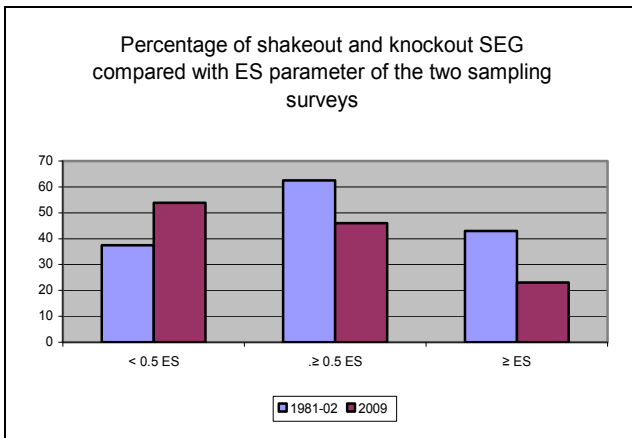


Figure 4: Proportion of the shakeout and knockout SEG exceeding either the action level or the ES

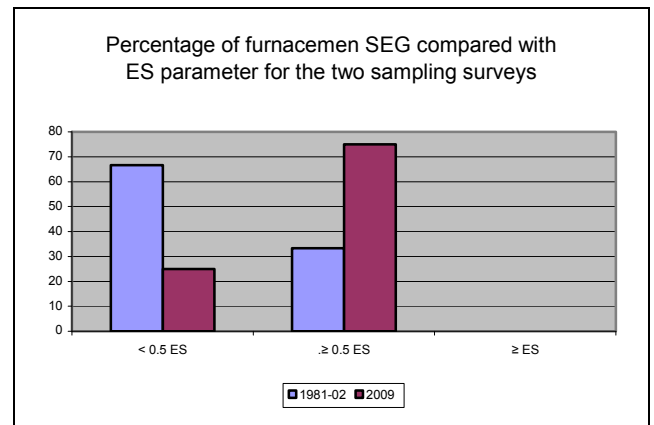


Figure 6: Proportion of the furnace man SEG exceeding either the action level or the ES

Aggregate respirable dust exposures

Table 1 (below) shows the averages of respirable dust exposures for all six SEGs for the two different survey periods. The information shown provides an immediate indicator of how well the dust levels are being controlled, irrespective of toxicity. High dust levels will generally indicate poor control; decreasing dust levels over time indicate improving control capability and probable improved compliance. Please refer to Appendix A1 for a more detailed explanation.

Table 1: Overall Geometric Mean (GM) respirable dust exposure in mg/m³ for the SEGs for the two survey periods

Similarly exposed group	1981– 2002 survey period		Current 2009 survey
	GM respirable dust concentration mg/m ³	ISO normalised GM respirable dust concentration mg/m ³	GM respirable dust concentration mg/m ³
Moulding	0.43	0.31	0.32
Sand plant, mixing and reclaim	1.64	1.17	0.46
Shot and abrasive blasting	1.67 *	1.19*	5.55*
Shakeout and knockout	0.92	0.66	0.35
Fettling and grinding	2.60	1.86	0.97
Furnace men	0.74*	0.53*	0.70*

* Arithmetic mean used as number of samples is small. Most average figures are shown as the geometric mean (GM). The yellow shaded band shows the GM of respirable dust exposure for all SEGs for the earlier survey period expressed in the equivalent new ISO measuring convention.

The yellow shaded band in Table 1 (above) converts 1981–2002 data to the common ISO measuring convention so that the pre- and post-2002 data can be directly compared (see discussion). RCS average exposures are shown below in Table 2. There are decreased exposures in three of the six SEGs, two remain static and only one has worsened.

Table 2: Average Geometric Mean (GM) RCS exposures for each SEG for the two survey periods

SEG	GM RCS exposure <2002	GM RCS exposure 2009	Relative average performance
Moulders	0.03	0.03	No change
Sand plant, mix and reclaim	0.18	0.08	Much better
Shot and abrasive blasting	0.06	0.16	Worse
Shakeout and knockout	0.09	0.03	Much better
Fettling and grinding	0.13	0.02	Much better
Furnace men	0.05	0.05	No change

Is the risk now being controlled more competently with RPE or ventilation controls?

Observations on the wearing of RPE to protect against both respirable dust and silica were made. Overall, the wearing of particulate respirators rose from 8 per cent in the earlier studies to 26 per cent in the 2009 survey. However, use of RPE was not confined to, nor always worn by, those with the highest RCS exposures. Figures 7 and 8 look at use of RPE specifically in terms of personal exposure exceeding the RCS exposure standard for each SEG. As shown, while nearly all workers with excessive exposures in the pre-2002 surveys failed to wear any RPE, in the 2009 survey overexposed workers without protection fell to 68 per cent.

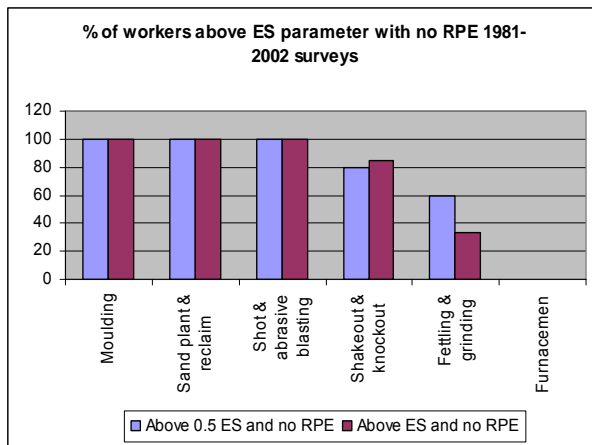


Figure 7: Proportion of workers in each SEG who exceeded either the 0.5 ES (Action Level) or the ES who wore no RPE 1981-2002

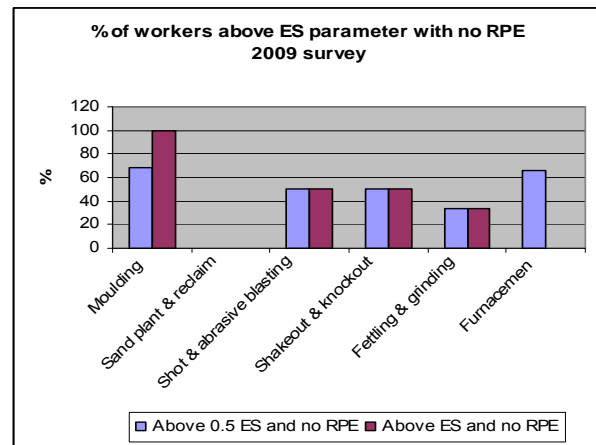


Figure 8: Proportion of workers in each SEG who exceeded either the 0.5 ES (Action Level) or the ES who wore no RPE 2009

Discussion (i.e. trends in exposure, compliance and controls)

Exposure

Firstly, between the first and second surveys (1981-2002 and 2009) the dust conditions in Queensland foundries show an improvement with a **downward trend** in three of the six SEGs, as shown in Table 1. These improvements are even more evident in the reduction in the occupationally relevant RCS exposures in Table 2. The shot blasting 2009 result is an aberration caused by one very high result. In the foundry industry, the extent of use of sand has not changed, though the amount of fine fume which contributes to overall respirable dust exposures has decreased as the result of increased use of fine mist fogging systems. The SEGs, for which there is no great apparent improvement, are the moulders (in large foundries, this group constitutes a significant part of the work force and, in the two different surveys, constituted one-third and one-half of samples respectively) and the furnace men. These tasks may have reached an irreducibly low level of exposure unless further significant effort is made to use ventilation controls. No specific exposure standard exists for respirable dusts in Australia (the American Conference of Governmental Industrial Hygienists—ACGIH recommends 3 mg/m^3). Most importance is placed on the RCS as the main health hazard.

Compliance

The second trend of regulatory interest is the **extent of compliance** with respect to RCS exposures (Figures 1–6). In overall terms, non-compliance with Regulation 205 (i.e. $> \text{ES}$) has fallen from a nominal 28 per cent in the early study to 21 per cent in 2009. Of these 21 per cent ($n=16$) requiring significant control, only 5 wore RPE and the remaining 11, constituting 14.5 per cent of all workers, had no protection. The majority of these were moulders.

The trend of most average RCS exposures and most individual RCS exposures is downward. However, because the RCS standard has become more stringent, there is an upward trend in the proportion of SEGs for which the exposure conditions now lie $\geq 0.5 \text{ ES}$, i.e. at or above the action level. About half the foundries in the most recent survey had work tasks in this category requiring review.

Controls

Use of RPE has increased markedly between the two survey periods from a recorded uptake of 8 per cent to 26 per cent of all workers. Figure 8 compared with Figure 7 shows that for most SEGs, the proportion of workers with no RPE amongst the heavily exposed has fallen dramatically except amongst moulders. All moulders with excessive RCS exposure wore no RPE. RPE was available to more workers in many foundries, but was not always used. Reasons for non-use varied from comfort issues to abhorrence of using it. In the main though, for many operations in foundries, there

is a genuine lack of perception about the risk since there are no real visual clues about the existence of the hazard. This is because respirable sized dust is essentially invisible and many foundries have not undertaken any independent sampling in recent times which would have confirmed the need for use of RPE or other controls.

Not all those with the highest exposures were properly protected. A total of 76 workers were monitored. Of these, 16 (21 per cent) had elevated personal RCS exposure \geq ES, and 11 of those 16 (or 68 per cent) wore no RPE in conditions where exposures ranged up to more than three times the exposure standard for respirable crystalline silica. The majority were either moulders or shakeout operators. Another eight per cent of workers wore RPE for part of their task; some had beards or used only one strap on disposable respirators. In the 2009 survey, 48 per cent of all monitored exposures were ≥ 0.5 ES_{adjusted} for RCS, and of these, only 30 per cent wore RPE of varying effectiveness. Some foundries which may have extensive use of powered air purifying respirators (PAPRs) were not included in the most recent survey.

Local exhaust ventilation is effectively used in many fettling, dressing and grinding operations (generally with a high level of compliance on RCS exposures). In some moulding sand delivery, hand mould shaping, and other operations involving sand pouring or pumping that have recorded very high peak exposures (in excess of 10 mg/m³), and where ventilation could prove very beneficial, there is mostly absent or poorly functioning ventilation and dust control.

Conclusion and recommendations

Crystalline silica has been subject to specific occupational health and safety regulation in Queensland for 15 years. Such regulations require stringent dust controls to be in place, as well as health surveillance (especially where it can be shown that the uncontrolled risk is significant).

Silica's potential to cause ill health in the foundry industry has long been known, but now has new health concerns attached to it. Overall, the Queensland foundry industry has recorded some significant improvement in both the exposure conditions over the last 30 years and in the uptake in use of respiratory protection. However, the lowering of the exposure standard for RCS in recent years has increased the need for competent control for those who are overexposed and unprotected, currently around 15 per cent. The largest SEG, the moulders, have shown only marginal gain and are responsible for the greatest extent of non-compliance.

In conclusion, much greater emphasis needs to be given to:

- more precise identification by foundries of those tasks where control is needed (i.e. more frequent assessment of dust conditions and RCS exposures)
- greater use of good quality RPE
Note: This includes ensuring the greater uptake of RPE where it is offered, correct donning of equipment, and having RPE tailored to suit the operator and the task. This may mean greater use of PAPRs in some SEGs.
- improved engineering solutions for dust control
- attention to major dust leaks in some abrasive blasting chambers and sand plants.

Because there is still a number of workplaces indicating significant risk (unprotected exposure > exposure standard) for a hazardous substance in Schedule 8 of the *Workplace Health and Safety Regulation 2008*, health surveillance must remain a consideration for this industry.

More information

Further information is available from www.worksafe.qld.gov.au or by calling the WHS Infoline on 1300 369 915.

The following publications are available on the website:

- *Silica and the lung – fact sheet*

- *Silica –identifying and managing crystalline silica dust exposure - Information guide*
- *Silica – managing exposure in the workplace: Occupational Disease Strategy 2007 – 2010*
- *Workplace Health and Safety Act 1995*
- *Workplace Health and Safety Regulation 2008*
- *Hazardous Substances Code of Practice 2003*
- *Foundry Code of Practice 2004*

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Appendix A1

Note: Results of the respirable dust and RCS exposures showing differently calculated means and confidence limits for all six similarly exposed groups for the two different survey periods. Respirable crystalline silica is highlighted in pink.

SEG		AM		ASD		GM		GSD		MVUE		LCL		UCL	
		<2002	2009	<2002	2009	<2002	2009	<2002	2009	<2002	2009	<2002	2009	<2002	2009
Moulders	Resp dust	0.59	0.50	0.51	0.73	0.43	0.32	2.32	2.35	0.61	0.45	0.45	0.36	0.95	0.62
	RCS	0.06	0.05	0.08	0.53	0.03	0.03	3.25	2.66	0.06	0.05	0.04	0.04	0.12	0.07
Sand Plant, mix & reclaim	Resp dust	2.19	0.83	1.90	0.64	1.64	0.46	2.24	4.39	2.19	1.03	1.47	0.45	4.70	64.9
	RCS	0.20	0.18	0.09	0.17	0.18	0.08	1.60	5.40	0.20	0.23	0.16	0.09	0.29	43.8
Shot & abrasive blasting	Resp dust	1.67	5.55												
	RCS	0.06	0.16												
Shakeout & knockout	Resp dust	1.10	0.40	0.61	0.18	0.92	0.35	1.92	1.92	1.12	0.42	0.86	0.31	1.65	0.65
	RCS	0.12	0.05	0.09	0.04	0.09	0.03	2.68	2.80	0.13	0.05	0.09	0.03	0.27	0.12
Fettling & grinding	Resp dust	2.96	1.68	1.64	1.42	2.60	0.97	1.70	3.50	2.94	1.92	2.22	1.09	4.59	7.54
	RCS	0.14	0.03	0.06	0.06	0.13	0.02	1.57	2.49	0.14	0.03	0.11	0.02	0.22	0.70
Furnace men	Resp dust	0.74	0.70												
	RCS	0.05	0.05												

All the following terms relate to the various dust concentration measurements:

AM = arithmetic mean

ASD = arithmetic standard deviation

GM = geometric mean of the lognormal distribution

GSD = geometric standard deviation

MVUE = minimum variance unbiased estimate

LCL = 95% lower confidence limit of the MVUE

UCL = 96% upper confidence limit of the MVUE

Most reliable information about the spread of results can be found by examining both the geometric means and their geometric standard deviations.