HSE

Health and Safety Executive

Silica baseline survey

Annex 2 Construction sector

Prepared by the **Health and Safety Laboratory**
for the Health and Safety Executive 2009

RR689
Annex 2

Health and Safety Executive

Silica baseline survey

Annex 2 Construction sector

Andrew Easterbrook
Paul Brough
Health and Safety Laboratory
Harpur Hill
Buxton
Derbyshire SK17 9JN

Aims and Objectives

This Silica Baseline Survey aims to develop baseline intelligence on exposure and control of respirable crystalline silica in key industry sectors. These sectors are:

- Brickworks and Tile Manufacture
- Stonemasonry
- Quarrying
- Construction

The objectives are:

1) to establish whether exposure control practices (both the application of engineering controls and the use of RPE) are adequate to reduce exposures below the WEL for RCS
2) to form an opinion about the long-term reliability of the controls
3) to identify common causes of failures of exposure control
4) to provide data by which the effect of HSE interventions can be assessed.

This annexe to the main SBS report includes the site visit data and detailed discussion of observations in the construction sector.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the author alone and do not necessarily reflect HSE policy.

HSE Books

First published 2009

CONTENTS

EXECUTIVE SUMMARY

This Silica Baseline Survey aims to develop baseline intelligence on exposure and the control of respirable crystalline silica in key industry sectors. These sectors are:

Brickworks and Tile Manufacture

Stonemasonry

Quarrying

Construction

The objectives are:

1) to establish whether exposure control practices (both the application of engineering controls and the use of RPE) are adequate to reduce exposures below the WEL for RCS
2) to form an opinion about the long-term reliability of the controls
3) to identify common causes of failures of exposure control
4) to provide data by which the effect of HSE interventions can be assessed.

This annexe to the main SBS report includes the site visit data and detailed discussion of observations in the Construction sector.

Main Findings

Many activities in construction are capable of generating dust and RCS concentrations considerably above WELs, possibly more so as higher powered tools develop. Exposure above the WEL was measured at four sites out of the 9 visited and was foreseeable in a fifth case.

The employers visited had underestimated the extent of exposures, and in many cases had not made the implementation of exposure control a priority.

Assessment of "control competence," i.e. the robustness of the systems underpinning the effectiveness of engineered exposure controls or Respiratory Protective Equipment, suggests that employers who have made assessments are likely to maintain effective ongoing exposure control, those who have not are not likely to achieve control.

Adoption of engineered controls as standard would in most cases reduce exposures to within WELs. Conversely, where controls are not applied (e.g. dry grit-blasting buildings or cutting out mortar without effective on-tool extraction) exposures can greatly exceed WELs.

RPE competency is not adequate to ensure reliable protection when engineered controls are not applied.

Where high-value plant has been introduced (e.g. rock-drilling machines in tunnelling, crushers at recycling plants) dust suppression measures are more likely to have been installed than where small items of plant are in use.

The activities considered and the sites visited were a very small proportion of a very large and diverse industry: The data is insufficient to allow any wider extrapolation (either to activities not examined or to other employers) but it is considered that an important general principle has been illustrated. This is that in the absence of a formal approach and structured controls unacceptable exposures are likely to occur.

1 INTRODUCTION

1.1 SILICA BASELINE SURVEY

HSE has established a Disease Reduction Programme (DRP) as part of the FIT3 strategic programme. The aim of the DRP is to reduce the incidence of work-related ill health caused by exposure to hazardous substances. Respiratory disease, covering occupational asthma as well as the longer latency diseases such as Chronic Obstructive Pulmonary Disease (COPD) and silicosis, accounts for a significant proportion of work-related ill health and so the DRP has a specific project to address this.

The Silica Baseline Survey is being undertaken to support the respiratory disease project and focuses on four industrial sectors where ongoing exposure to Respirable Crystalline Silica (RCS) is suspected. These are Construction, the Brick-making and heavy clay industry, Stonemasonry and Quarrying. This Annexe to the main SBS report contains the detailed descriptions of site visits, other exposure data, discussion and sector-related conclusions for the Construction industry. The work on the other sectors is reported in sister annexes.

This report takes forward much earlier HSE work. Many of the documents reporting such work have been quoted here, either directly or with alterations to make the information more specific to the activity under discussion.

1.2 SILICA AND HEALTH EFFECTS

Crystalline forms of silica (Quartz, plus the much less common minerals cristobalite and tridymite which form at high temperatures) are the commonest minerals in the earth's crust (matched by the feldspar group, according to some authors.). Quartz therefore forms a proportion of many raw materials used in construction. When silica-containing materials are crushed or abraded the silica crystals are split or shattered to release fragments of a range of sizes. Most significantly, a proportion of them are sufficiently small that if they are inhaled they evade the various air-cleaning mechanisms of the human respiratory tract and penetrate to the depth of the lung where gas-exchange takes place. Particles of this size range are termed "respirable" and are known to be associated with disease.

Historically, exposure to respirable crystalline silica (RCS) in a wide variety of workplaces has caused a large burden of serious and often fatal respiratory disease. Exposure limits have been imposed and controls have been required but it has not been practicable thus far to reduce exposures sufficiently to eliminate disease.

In a discussion paper produced before the UK exposure limits were reduced in 2006, (HSE 2003) HSE looked at the consequences of exposure across the whole of UK industry in a range of circumstances. HSE predicted that the following number of silicosis fatalities would be prevented over a sixty-year period at the various possible exposure limits:

Table 1 Estimates of silicosis fatalities at different exposure limits

Potential Exposure Limit (8hr TWA)	Deaths prevented
0.3 mg.m^{-3}	36 fatalities / 1 PA
0.1 mg.m^{-3}	185 fatalities / 3 PA
0.05 mg.m^{-3}	300 fatalities / 5 PA
0.01 mg.m^{-3}	455 fatalities / 8 PA

Exposure to RCS clearly represents a significant ongoing health hazard wherever earth-derived raw materials or products are worked and HSE is addressing respiratory disease as one strand of the Disease Reduction Programme, part of the "FIT 3 initiative." This report focuses on the work done to assess the position regarding RCS exposures in the construction industry, one work area where an ongoing health risk is considered possible. The detailed information shown here is summarised in the parent report which draws together the HSL work on the SBS.

RCS is subject to a Workplace Exposure Limit (WEL) which was reduced from 0.3 to 0.1 $mg.m^{-3}$ during the course of this study. Respirable dust (or other particulate) is also subject to control under the COSHH Regulations "when present at a concentration in air equal to or greater than 4 $mg.m^{-3}$, as a time-weighted average over an 8-hour period." Strictly therefore the duty to apply the principles of good control practice applies when this threshold is exceeded.

This report takes forward much earlier HSE work. Many of the documents reporting such work have been quoted here, either directly or with alterations to make the information more specific to the activity under discussion.

1.3 HYGIENE STANDARDS

In the UK exposure to RCS is regulated under the Control of Substances Hazardous to Health Regulations 2002 (as amended) (HSE 2002 and 2004.) There is a duty to apply the "Principles of good control practice" listed in Schedule 2a of the Regulations and exposure should not exceed the Workplace Exposure Limit (WEL) set in EH40, (HSE 2005.) The WEL that applied at the start of this project was 0.3 $mg.m^{-3}$ and it was reduced to 0.1 $mg.m^{-3}$ in October 2006. The new limit was included in the updated List of approved workplace exposure limits published by HSE in 2007 (HSE 2007).

The Social Dialogue Agreement for silica (SDA) (ref NEPSI) is a parallel initiative, agreed at European level. A number of Industry Sector Associations have made a binding agreement to implement the requirements of both the exposure monitoring and reporting protocol and the associated "good practice guides." The good practice guides are similar to the COSHH Essentials guidance published by HSE and, if implemented in full, should result in exposures below the WEL. Although the SDA is not binding on employers who are not members of the participating trade associations, the nature of NEPSI makes it clear that all the actions suggested in the guidance are acknowledged as practicable by employers, and other organisations should therefore also be able to adopt the same standards.

1.4 OVERVIEW OF THE CONSTRUCTION INDUSTRY

The construction sector of UK industry is large and economically important, accounting for a significant proportion of both the UK's employment and Gross Domestic Product. It is also extraordinarily diverse from almost any point of view, whether one considers the employment structure, the technology applied during the activity, or even the value of any particular contract. There are house-building companies with a national presence and internationally renowned civil engineering contractors and there are also over 150,000 companies employing fewer than 5 employees. (Detailed employment figures are based on Office of National Statistics publications discussed in more detail in section 4 below.) Work ranges from the smallest-possible enterprises using techniques effectively unchanged for centuries to highly-organised activities such as tunnelling, where unmatched professional expertise is applied and one single item of plant alone (the tunnel-boring machine) may cost many millions of pounds. Construction may be new-build using entirely virgin materials, taking place relatively isolated from other people on a new industrial or housing estate, it may involve relatively simple alteration or cleaning of the exterior of an building or it may involve the extensive alteration of offices or dwellings still being occupied.

What all participants have in common, however, is that (apart from certain trades such as plumbers, electricians or woodworkers) they are likely to be working with products not far removed from their earth-derived raw materials. The nearly ubiquitous presence of quartz in the earth's crust makes it likely therefore that if any respirable dust is generated there is a significant risk of RCS exposure. Even tradesmen working exclusively with wood, metal or plastic may be subject to indirect RCS exposure if debris from other work migrates or is re-suspended due to the failure to use good control practice at an earlier stage of the work. There may also be totally unsuspected RCS exposure from working silica-loaded polymer materials, for example.

The production of some materials used in the industry (the quarrying of aggregate and making bricks) are recognised causes of silica exposure and have been considered separately within the SBS, as has stonemasonry.

A large proportion of the products and materials likely to be encountered in the construction industry contain a significant proportion of crystalline silica. Examples are listed below:

Products containing crystalline silica

Brick – up to 30%

Concrete, “cement” mortar 25 to 70%

Plastic composites – up to 80%

Tile – 30 to 45%

A large proportion of the materials likely to be disturbed in the course of site preparation or excavations also contain a significant proportion of crystalline silica:

Common earth materials - crystalline silica concentrations

Sand, gravel, flint - more than 70%

Sandstone, gritstone or quartzite – more than 70%

Shale - 40 to 60%

Clay subsoil – up to 40%

Relevant processes:-

The range of activities within construction is exceptional, ranging from the simple digging of a trench in damp shallow subsoil using a spade, to erecting a multi-storey tower block by a multiplicity of processes both basic and sophisticated. Indeed the range is so great that no detailed overview will be attempted here. The majority of processes involved are likely to involve the moving, shaping or re-shaping of materials derived from the earth’s crust, however, and therefore usually either (deliberately or incidentally) containing a proportion of quartz.

If sufficient energy is applied in the course of the process that necessarily or incidentally causes fracturing of silica grains and if a control mechanism is not applied (or fortuitously present) the generation and subsequent inhalation of RCS is likely. This may be seen in the example of drilling into a wall either for a fixing or to pass a cable or pipe, when a hammer-drill with a masonry bit may be used to penetrate plaster then brick or concrete blocks bedded in cement mortar. The plaster may have been made from gypsum which originally formed by evaporation in a shallow sea and therefore may contain a little crystalline silica. Similarly the bricks are usually made from clay, a marine or lake sediment also containing quartz, while the cement mortar and concrete blocks are almost by definition quartz-containing sand or larger aggregate grains bound in a cement paste matrix. One type of brick is made entirely of pure silica sand bonded by calcium silicate.

Even activities not involving silica may expose workers to re-suspended RCS if dried dust deposits, for example on site roadways, are disturbed.

1.5 HISTORICAL EXPOSURE DATA AND RESEARCH PAPERS

Previous studies of RCS exposure in the Construction sector have shown that occupational exposure to RCS varied considerably across the various sectors and activities within UK industry.)

(It should be noted that in all discussion of exposure data there is a discontinuity at 1997. This is because in January 1997 the UK adopted the ISO/CEN convention for respirable dusts as defined in BS EN 401. To maintain the equivalent level of control the MEL for respirable crystalline silica was reduced from 0.4 $mg.m^{-3}$ to 0.3 $mg.m^{-3}$ when sampled by the new convention.)

HSE Work

An internal HSE report (Technical Development Survey (TDS) – Silica In Construction: Northage & Heathfield 1995) described an investigation of silica exposures across a wide range of activities. These included building, bridge & roadway repair/restoration, tunnel construction, machining of concrete and stone floor polishing.

The project originated from the review carried out for the setting of a new occupational exposure limit for RCS (the then Maximum Exposure Limit of 0.4 $mg.m^{-3}$ 8hr TWA).

It showed that in the construction activities monitored a large number of activities gave rise to exposures to RCS greater than 0.1 $mg.m^{-3}$. The highest exposures, some of which were in excess of 1.0 $mg.m^{-3}$, occurred during repairing of brickwork, channelling cement and tunnelling. Brickwork repair and cement channelling involved the use of power tools whilst tunnelling is necessarily performed in confined spaces.

The report also highlighted the frequent inadequacies in the provision and training and maintenance with regard to RPE. A similar picture emerged for the use of LEV and other engineering controls.

The study highlighted the magnitude and extent of exposures to RCS that can occur during construction activities and the need for improvements in workforce training & supervision and also the selection, use and maintenance of RPE and engineering controls. The results of this study are summarised in table 1 in Appendix A of this report.

In 2003 HSE issued a questionnaire on RCS exposure. The results were reported in the Regulatory Impact Assessment (RIA), HSE and are included in this report as Table 2 in Appendix A. From the limited number of replies from the construction industry, it was believed that currently no employees in the construction sector were exposed to RCS levels above 0.3 $mg.m^{-3}$, none were exposed to RCS levels above 0.1 $mg.m^{-3}$, about 9% were exposed to RCS levels above 0.05 $mg.m^{-3}$ and about 9% were exposed to RCS levels above 0.01 $mg.m^{-3}$.

An earlier HSE-commissioned study (Chisholm 1999) produced a summary of a range of task-based RCS exposures and showed that in general work 30% of samples were above 0.3 $mg.m^{-3}$ and 65% of samples were above 0.1 $mg.m^{-3}$. In tunnelling, 18% of samples were above 0.3 $mg.m^{-3}$ and 27% of samples were above 0.1 $mg.m^{-3}$.

Other Published research

In 1996, the American Occupational Safety and Health Administration (OSHA) examined its RCS data collected between 1980 and 1995. (Yassin et al, 2005.) 37% of 728 samples were above 0.1 $mg.m^{-3}$. As well as masonry, drill setting, other stone-work, tunnel working and heavy construction other tasks less obviously involving RCS exposure such as painting and paper hanging showed high exposures, although these may have involved surface preparation.

A more recent report titled 'Excessive Exposure to Silica in the Construction Industry' (Rappaport et al. 2002) concluded "urgent action is required to reduce silica exposures in the US construction industry". The report statistically analysed exposure data (generally full-shift measurements) from worker exposures to respirable dust and silica across 36 construction sites in the USA. Personal measurements (n=151) were taken from 80 workers in four construction trades, namely bricklayers, painters (only while abrasive blasting, where RPE was always used), [plant] operating engineers and labourers.

In the U.S.A. the Occupational Exposure Limit (OEL) for RCS is 0.05 $mg.m^{-3}$ 8hr TWA and the study estimated that the probability of over-exposure (i.e. in excess of the OEL) to be between 64.5 – 100%.

Although it is not clearly explained in the report, the abrasive blasting undertaken by the painters is understood to be a process using similar equipment to the abrasive blast cleaning that was monitored during the SBS. It should however be noted that the Rappaport study makes reference to the use of sand or coal slag as the abrasive. Both of these substances are likely to contain quartz and their use as blast abrasives is therefore prohibited in the UK. The exposures recorded in the US study for these operations are therefore unlikely to be comparable to UK exposures where the use of non-quartz abrasives would remove one potential source of exposure to RCS.

The US study commented that the silica exposures were significantly reduced by the use of wet dust suppression and use of ventilated cabs (operating engineers).

The following two figures are reproduced from the US study and illustrate the range of measurement results.

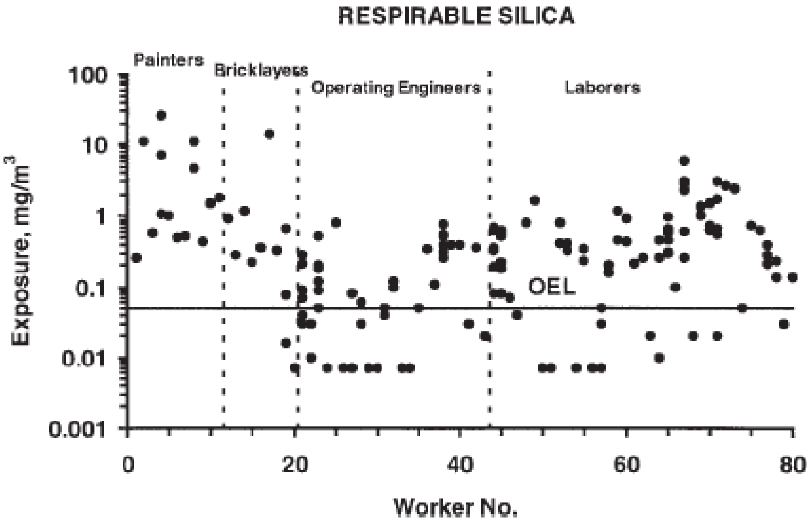

Fig. 1. Exposures to respirable dust and silica among 80 construction workers in four trades. Each point represents a personal measurement. The OELs are 0.05 mg/m³ for respirable silica (NIOSH, 1975; ACGIH, 2002) and 3 mg/m³ for respirable dust (ACGIH, 2002).

(The horizontal line in Fig. 1 indicates the U.S. OEL of 0.05mg/m^{-3}.)

Table 3. Median levels and ranges of respirable dust and silica exposures for workers in four construction trades

Trade	*n*	Dust (mg/m³)			Silica (mg/m³)		
		Median	Range	Max/min	Median	Range	Max/min
Painters	14	13.5	1.16–833	718	1.28	0.260–26.2	101
Bricklayers	11	2.13	0.160–29.0	181	0.320	0.007–14.2	2030
Operating engineers	46	0.720	0.01–3.00	300	0.075	0.007–0.800	114
Laborers	80	2.46	0.01–21.0	210	0.350	0.007–5.90	843

n, number of measurements.

The study considered the greatest concern to be the large exposures observed amongst Bricklayers and Labourers. Work activities covered under the Bricklayers category included those in construction or renovation of buildings using hand drills, grinders, saws and jackhammers, primarily working outdoors. The Labourer category covered activities at ground level including the use of hand drills, saws, jackhammers, chipping guns, rakes and brooms. It was observed that these workers were routinely exposed to RCS in the range of 0.1 to –1 mg.m^{-3} and rarely wore any form of RPE.

The data from the study indicated that there was a greater degree of between-worker variance in exposure than within-worker exposures, and that construction work is characterized by large differences in average exposures between members of the same trade. This means that it would require a major exposure data collection exercise, involving many visits to individual sites, activities and types of equipment, in order to gain an accurate exposure profile for an activity and to develop effective intervention strategies for the different trades within the construction industry.

Alongside the Rappaport study the other most recent large-scale study of worker exposures to RCS in the construction industry was undertaken in the Netherlands by Lumens and Spee (2001). 171 task-based personal exposure samples were taken across 30 construction sites focussing primarily on three activities; recess milling (i.e. conduit chasing), inner wall construction and demolition work. The geometric mean RCS exposures for the three working groups were as follows:

Recess millers (n=53) – 0.7 mg/m3

Inner wall constructors (n=36) - 0.04 mg/m3

Demolition workers (n=82) – 1.1 mg/m3

Total population (n=171) – 0.5 mg/m3

With the exception of "inner wall construction" the activities included in the study were demonstrated as being capable of producing extremely high exposures to RCS.

The study also used statistical analysis of the exposure data in an attempt to demonstrate the contribution of different determinants to the total exposure from a construction activity. The determinants considered were; agent (type of stone or % silica content), process and appliances used, working environment and work practice.

The multiple source model produced was, in the author's opinion, able to produce relevant information on the contribution of the different determinants. The determinants could then be prioritised and control measures designed that would effect the greatest potential reduction in RCS exposure. Using this approach the design of control strategies for construction activities identified as having high dust or RCS exposure problems could be structured. However this model is reliant on sufficient, reliable exposure data being available for the construction activity in question.

The author noted that the most important conclusion of the study was that there existed a clear need to raise the awareness of the hazard of high exposures to RCS and associated risk to health in the construction industry.

The Rappaport study suggests and the Lumens study indicates that the true extent of RCS exposures within the construction industry could only be accurately assessed following detailed investigation into RCS exposures across the large number of various construction activities and the working environments where they are performed.

Effect of engineering control on Exposure

A paper produced in 2003 (Flynn & Susi) reviewed literature under the title "Engineering controls for selected silica and dust exposures in the construction industry."

The paper summarises the results of reports of a wide range of engineering control technologies employed in the construction industry to control worker exposure to silica whilst undertaking a range of selected tasks. The commonest controls employed were found to be wet methods and LEV. The study suggested that, while the methods provide substantial RCS exposure reductions, they might not reduce levels below the ACGIH threshold limit value (TLV) of 0.05 mg.m-3. The report concludes that effective methods exist for significant RCS exposure reduction in the construction industry.

Below are summaries of some of the main findings of the review conducted as part of the research;

<u>Brick mortar removal prior to re-pointing</u>

The research looked at a number of previous studies which indicated high dust exposures for these operations when undertaken with no form of ventilation or dust suppression. In one study cited by Flynn & Susi (Heitbrink, W.A. 2000) ten personal samples during uncontrolled grinding produced respirable dust exposures ranging from 5.4 to 16.9 mg.m^{-3} and RCS ranged from 1.29 to 2.8 mg.m^{-3}. All samples exceeded 500 minutes duration.

A wet method used in conjunction with LEV reduced exposures: respirable dust concentrations of 0.59 & 0.38 mg.m^{-3} were achieved (measured over a 1hr period.)

The research highlighted a number of issues associated with the engineering controls including the potential electric shock hazards from wet systems and also the necessity for a sufficient flow rate for any extraction fitted.

Another study discussed by Flynn and Susi (Croteau, 2000) further emphasised the large exposure reductions potentially achievable. A table summarising these results is presented below:

Summary exposure data for mortar removal using an angle grinder (prior to re-pointing)[A]

Control	Geometric mean, respirable dust (mg/m^3)	G.S.D., respirable dust	Geometric mean, respirable quartz (mg/m^3)	G.S.D., respirable quartz
No vent N = 14	22.17	2.42	3.04	1.98
Low vent (30 cfm) N = 14	6.11	1.85	1.02	1.76
High vent (70 cfm) N = 13	3.01	3.31	0.47	3.27

Surface Grinding Operations

Another recent study (Akbar-Khanzadeh, 2002) looked at the exposures of workers grinding concrete in a standing position. 15 of the 49 samples were on workers using tools fitted with LEV and for these the mean RCS exposure was 0.38 $mg.m^{-3}$. For the workers grinding without LEV the mean RCS exposure was 1.5 mg.m-3.

Cutting & Sawing Operations

The study made reference to previous research undertaken at HSL into the effectiveness of dust control on cut-off saws in the construction industry (Thorpe et al. 1999). This had used field and laboratory tests and had demonstrated that the use of water suppression systems could produce a ten-fold reduction in the respirable dust concentrations generated during stone cutting activities. Similar water dust suppression systems were observed at a number of the field studies conducted during the SBS and the results obtained indicated that these were effective in reducing worker exposures to RCS below 0.1 $mg.m^{-3}$ 8hr TWA. Further details of these field studies can be found in Appendix II of this report.

NIOSH (US) investigators (Heitbrink, W.A. 2001) studied the dust concentrations generated by a stationary masonry saw. This was done in a laboratory with dust measurements made when it was being operated both with and without LEV. When no LEV was present the respirable dust concentration “in the extract tunnel” was 13 $mg.m^{-3}$; with the LEV system active (extracting both below the brick and from the blade guard) “the extract tunnel respirable [dust] concentration dropped to 0.05 $mg.m^{-3}$.”

2 SBS SITE ASSESSMENT METHODOLOGY

2.1 SITE SELECTION

Due to the nature of the industry's structure (composed of large numbers of small and micro-businesses as well as large organisations) a comprehensive survey to identify the distribution of good and bad hygiene practice across the construction would have been difficult and very expensive. The principal focus was therefore on businesses whose operations involved construction activities known to pose significant risk of exposure to RCS, in particular:

- Businesses utilising plant & equipment capable of generating significant concentrations of dust (e.g. hand-held power tools).
- Activities where developments in dust control technology may have led to the possibility of reductions in RCS exposures.

Initial discussions with businesses were undertaken in order to determine the type and standard of any engineering control measures employed to deal with dust hazards. In considering their exposure control strategies good practice was identified by items such as innovative or well-designed engineering controls, good health & safety management etc. Bad practice included evidence of overexposures, ineffective or poorly designed engineering controls and poor health & safety management.

Information published by the UK Office of National Statistics (ONS) was consulted to explore the breadth of the industry and to suggest high-risk activities. Construction forms Division 45 of the ONS "UK Standard Industrial Classification of Economic Activities 2003 – SIC (2003.)" The range and detail of the subdivisions within Division 45, Construction is shown in Appendix C.

A limited range of Construction activities were selected for monitoring visits, including highway (footpath) maintenance, concrete recycling, blast cleaning and tunnelling operations.

Construction businesses of differing size and capacity were included, ranging from small businesses through a local authority Direct-Labour Organisation to the concrete-recycling plants of a business with a nationwide presence.

After a sufficient number of suitable sites had been identified in each area those selected for inclusion in the survey, with the exception of those previously visited by HSE, were chosen at random. The baseline survey field studies for the construction sector comprised twelve visits to sites and the field studies were conducted by representatives of HSL between December 2005 and May 2007.

The majority of sites volunteered to participate in the survey. Some sites were visited with a representative from HSE FOD.

2.2 ASSESSMENT OF CONTROLS

The objective of the SBS was to gather information on the current effectiveness of RCS exposure control in the selected parts of UK industry as well as to measure exposures. A full explanation of the procedure adopted is given in the SBS main project report, but is summarised briefly below.

An important aspect of this study is that control competence is not judged simply by measurement of exposures. The success of exposure control depends on the correct application of a wide variety of measures. Control of emission at source (by engineered controls) is recognised as the most effective measure, but in some circumstances is not practicable, and the use of RPE is necessary to maintain exposure at a safe level. However the ongoing effectiveness of all exposure control regimes depends on the underpinning actions being maintained, termed "competency" here. The SBS site visits assessed the resilience of the control regime by considering the robustness of the range of factors involved. This technique was applied because it was expected to give a better assessment of whether exposures would be likely to remain within the WEL than would a single day's measurement. The views and professional opinion of the visiting occupational hygienist were therefore captured in a structured way that allowed an objective assessment of competence to be made. The same criteria could then be used at some future date to judge change.

It should be noted that the Control competence ratings ranged from 0 to 5, where 0 indicated manifest failure and was numerically valid.

A similar assessment was made of the effectiveness of the RPE regime if use was necessary to maintain control of exposure. For RPE competence a rating of N/A was included instead of 0, which indicated adequate control by other methods. However this does not address the residual need which has to be acknowledged, e.g. for circumstances when engineered controls have to be worked on. The factors considered are shown in the site competency assessment checklists, which are reproduced in appendix 5 of this annexe. A shift in the profile of these indicators will provide strong evidence of the desired improvements in the industries. The factors themselves are shown below:

"Control competence" was assessed by

- Comprehensiveness of COSHH assessment
- Awareness of literature and information sources
- Application of appropriate, effective, well maintained controls at process
- Degree of management and operator understanding of exposures
- Level of operator training
- Designation of areas and use of RPE when appropriate
- Well informed management
- Competence of supervision

i.e. overall evidence of coordinated approach to control – skills and knowledge available

"RPE competence" was assessed by

- Verifiable policy on RPE linked to COSHH assessment.
- Face fit testing programme
- Equipment routinely available and range of products available through selection process
- Appropriate storage facilities
- Initial training and refresher training
- Operator understands role of RPE in controlling exposure
- Clearly defined roles and responsibilities

Achievement of a rating of 4 for control competence and, if necessary, for RPE competence, was intended to identify sites which "achieved the COSHH Essentials standard." This indicated a system of exposure control sufficiently robust that ongoing compliance with the WEL could be anticipated. A grade of 5 would have indicated exemplary performance in every aspect of control: it was not seen anywhere.

Worker exposure to airborne respirable dust and RCS was measured during the time on site and generated a further input to the baseline survey. It has to be recognised that the results of the monitoring show exposures as they were on the day, when a visit was made by appointment.

2.3 EXPOSURE MONITORING

Worker exposure to airborne respirable dust and RCS was measured during the time on site and generated a further input to the baseline survey. It has to be recognised that the results of the monitoring show exposures as they were on the day, when a visit was made by appointment.

A summary describing the activity, conditions, controls and data from each site report is shown in Appendix B of this document, together with a summary line that is carried forward to the overall data table, included as table 6 in Appendix A.

3 RESULTS

Control and RPE competence assessments

Of the 8 sites awarded a rating for adequacy of control measures, 3 sites achieved a rating of 4, i.e. achieved a level of control that would be deemed appropriate as per COSHH Essentials. One was allocated 3 and the remaining four sites received ratings of 2.

Table 2 Distribution of control competence ratings

Control Competence Rating:	**0**	**1**	**2**	**3**	**4**	**5**
Number of sites:			4	1	3	

(Range: 0, "Manifest failure to recognise hazard and failure to provide any form of controls," 4: The COSHH Essentials Standard, 5: Exemplary control consistent with risk. Detail in Appendix D)

The average rating awarded across the nine sites was Rating 3, which can be summarised as '*Occasional over-exposure. Reasonable awareness of hazard and risk and desire to improve.*' This summary of control could be considered to appropriately reflect the overall picture of the industry obtained from this study. Although the result of a very small sample, the bimodal distribution is noteworthy.

Of the 7 sites awarded a rating for adequacy of RPE, no sites achieved a rating of 4, i.e. they did not achieve a satisfactory standard where there would have been strong evidence of selection of suitable and adequate equipment and good practices in use.

Table 3 Distribution of RPE competence ratings

RPE Competence Rating:	**N/R**	**1**	**2**	**3**	**4**	**5**
Number of sites:	1		5	3		

Three sites achieved a rating of 3 and the remaining five sites were awarded a rating of 2. One site was not awarded a rating as RPE was neither provided nor utilised.

The average rating awarded across the eight sites was Rating 2, i.e. '*RPE used to achieve adequate control. Evidence of provision of suitable and adequate equipment but strong evidence of poor practices in use*'.

The principal issue identified with the provision and use of RPE was the lack of face fit testing conducted. Regulation 7 of COSHH states that the initial selection of RPE (full / half face masks including disposables) should include fit testing to ensure that the correct device has been chosen (in terms of size and fit etc.). All site H & S representatives [officials] to whom this non-compliance was identified said that they would address this issue as soon as possible or that they had already taken steps to achieve compliance.

Note: No rating was made at any site where RPE was neither provided nor utilised. None of these sites had a standard of control deemed appropriate as per COSHH Essentials i.e. all were awarded competency ratings of lower than 4. Therefore it can be assumed that the reasons that RPE was not introduced may have been because of a false assumption that existing control was satisfactory at these sites.

Exposure monitoring:

Of 29 personal measurements of exposure made during the study, 4 (or 14%) indicated 8-hour TWA exposure above the (new) WEL of 0.1 $mg.m^{-3}$ RCS. All 4 samples came from different sites: 2 were taken during the removal of mortar prior to repointing buildings, one was from a concrete recycling plant and the other was taken during the grit-blasting of a sandstone building façade. This reflects the observations of control competence, in that the inability to apply controls to adequately "engineer out" exposure in over half the sites visited would be expected to have influenced exposures. Two assessments of exposure made during tunnelling work indicated that with the installed dust suppression on the equipment, rock drilling would not be likely to cause exposure above the WELs for RCS. Shotcreting, however, generated particulate that might cause exposure to respirable dust above the WEL.

In the rest of the survey 4 samples also revealed exposure to respirable dust above 4 $mg.m^{-3}$, the threshold at which it becomes a “Substance Hazardous to Health” and thus within the scope of the COSHH regulations. These samples were all from building restoration or maintenance operations, characterised by small peripatetic teams often working as franchisees of organisations with a national presence principally in a marketing role or supplying equipment.

4 DISCUSSION

Exposure Limits

"The COSHH definition of a substance hazardous to health includes dust of any kind when present at a concentration in air equal to or greater than…4 $mg.m^{-3}$ 8-hour TWA respirable dust. This means that any dust will be subject to COSHH if people are exposed above these levels." This direct quote from EH40 paragraph 42 of the Supplementary information for Table 1 makes it clear that there is a duty to apply the principles of good control practice when high dust exposures might occur.

RCS however is subject to a WEL: COSHH considers control of exposure to a substance hazardous to health only to be adequate if the WEL for that substance is not exceeded. This means that the 8-hour TWA exposure to RCS should not exceed 0.1 $mg.m^{-3}$ (the WEL was 0.3 $mg.m^{-3}$ until October 2006.)

General

This study does not continue the consideration of the cost of compliance with WELs or of the implementation of controls that formed part of the RIA. However the costs of controls do have an effect on the businesses that require them, and the following comments explore the financial context of business size and structure as it affects the implementation of controls.

The majority of (the very large number of) UK construction sector businesses are small or micro businesses: approximately 80% have fewer than five workers and 95% have fewer than 20, whether one considers "local units in VAT-based enterprises" or "VAT-based enterprises." (Where differences exist between the two they reveal something about the organisational structure of the businesses.) Of "VAT-based enterprises," 14% reportedly have an annual turnover less than £50k, 43% have a turnover below £100k and 71% have an annual turnover below £250K. (Source: 2005 ONS figures shown in Tables 3, 4 and 5 in Appendix A.)

Two other aspects of employment (but which are not quantified here) are that among the construction workforce a) there has always been a proportion of relatively lowly-skilled transient workers and b) there is a growing proportion of workers whose mother tongue is not English. . These factors have consequences for both the ease or effectiveness of training and the retention of knowledge. These are challenges that are not confined to the construction industry, however.

With the improvements to dust control technology made over recent years, particularly for power tools, there is considerable potential for the reduction in worker exposures to RCS across the construction industry. However the extent of the reductions will be greatly dependent on these controls being introduced and effectively utilised. The bimodal distribution of the control competence gradings reflects this. The 3 employers which were graded 4 received this rating as a net outcome of a range of actions that they had taken based ultimately on the fact that they had addressed dust and RCS exposure and installed engineered controls. A single employer received a grading of 3 and a further group who had not engineered out exposure were graded 2.

Regardless of company size or structure, construction businesses will generally hire specialist equipment or plant which may be required for only a short duration during the work, avoiding both the costs of outright purchase and of maintenance (and testing, where applicable). On many pieces of hire plant or equipment the dust control technology (e.g. water suppression) may be offered as an optional extra. Additionally some pieces of plant or equipment (e.g. drills, routers, angle grinders etc.) can come in two forms; with and without LEV fitted. The equipment without LEV fitted generally has a lower hire cost. It is therefore possible for construction businesses to reduce the costs associated with equipment hire by selecting the cheapest option, i.e. without dust control. In the light of the size and turnover of many employers this represents a very real pressure against using equipment with the best dust suppression available and probably accentuates the division between employers who recognise the risks of RCS exposure and have policies to minimise it and those who do not.

Any visit to a DIY superstore or construction wholesale yard will reveal that the RPE that is marketed as being suitable for use with power tools working such materials as concrete (thus probably generating RCS) and hard or softwoods (known carcinogens and sensitisers) is a respirator of some sort with P2 grade particulate filtration. The assigned protection factor for a P2 grade filter is 10, meaning that, if utilised correctly, the respirator reduces the wearer's exposure to one tenth of what it would have been without it.

A review of the typical dust levels generated for many of the construction activities involving power tools has demonstrated that extremely high concentrations of airborne RCS can be generated in very short periods. A protection factor of 10 might be completely inadequate in many circumstances. Without the presence of dust control measures on portable power tools such as saws and cutting wheels, etc., significant exposures may occur as a consequence of a minor part of a construction worker's various duties in a day.

The nature of the work undertaken by labourers in the construction industry is such that they may spend much of their working day undertaking a range of tasks which may only be of limited duration, e.g. sweeping dust from a work area, drilling a hole in some brickwork, chasing a cable run in a wall, cutting bricks to required shapes etc. The risk of exposure to RCS amongst these various tasks can vary considerably and may not be immediately apparent to the worker. If a worker has to do a task for a short duration he may consider it not worth the effort to get his RPE and utilise it for the task.

The cost pressures on firms are thus compounded by the potential low appreciation of the risks and consequences of RCS exposure among a workforce which is difficult to communicate with effectively. This is of concern because where PPE (Respirators) are relied upon to control exposure, the effectiveness of the measures depends heavily on the personal discipline of the wearer, which is itself a function of training, understanding and motivation. These are all factors difficult to maintain in a casual workforce with language problems.

There is therefore a value in removing responsibility for exposure control from the worker and from the site manager as far as possible. If power tools are only available in models which incorporate dust suppression or collection and a further feature is that the power to the machine is interlocked with the dust suppression feature it is more likely that control will be achieved. This applies particularly to items of equipment such as Stihl saws or abrasive cutting wheels. The benefits showed in tunnelling, where the drilling machines used before blasting incorporated water dust suppression and respirable particulate did not exceed 0.3 $mg.m^{-3}$ during the work.

Research such as the Rappaport study would indicate that the industry perception of the scale of exposures to RCS across construction activities is hugely optimistic. Industry responses to the HSE RIA questionnaire estimated that about 9% of construction workers were exposed to RCS levels above 0.05 $mg.m^{-3}$. The Rappaport study estimated that the probability of RCS exposure levels above 0.05 $mg.m^{-3}$ to be between 64.5 – 100% within the US construction industry. The SBS assessments of control competence (50% graded "2") suggest that effective ongoing control of RCS exposure is unlikely in the UK too.

Activities

In kerb and slab cutting, water fed to cutting wheels effectively suppresses dust release (although re-suspension of RCS from dried deposits is still possible.) Tools are available without dust suppression and "water-fitted" tools are useable without water, which both undermine the likelihood that this dust control will be applied. However there is an awareness of the high-value of saw blades and these are more likely to be protected from damage by the correct use with cooling water supplied (as opposed to the position regarding abrasive cutting wheels, which because they have a "sacrificial" cutting edge are generally considered to be disposable.) Anecdotal evidence and personal experience show that the cutting of stone and concrete without dust suppression continues, although the two employers seen for the SBS (gangs from a local authority DLO and a major contractor) did supply dust-suppressed tools which were correctly used.

During the grit-blasting of buildings two sites were seen where water suppression was not used for different reasons. At one location a summer water shortage was taken as an adequate reason not to use wet blasting. In fact it is doubtful that the hosepipe ban (as then worded) would have covered the activity, and the readiness to work without water indicates the low priority given to the minimisation of RCS dispersion by the dutyholder. The other blast cleaning operator claimed to need to work without water to avoid slurry accumulating in pockets of the carved stonework. The consequence was 8-hour TWA RCS exposure of 0.72 $mg.m^{-3}$. Again, this reveals the low priority given to preventing dust release, when one might expect wet dust suppression plus an additional final clean after the blasting had finished to have been a viable option.

Where mortar removal prior to repointing was seen, it was considered that the franchise structure focussed more on marketing and technical delivery, with less emphasis on support for COSHH assessments and other safety systems. Although efforts were being made to optimise the dust extraction on the cutting tools, the risk assessments for the work were not seen as a significant part of site procedures. (One tool manufacturer has now developed a reciprocating saw specifically for mortar removal, which is claimed to dramatically reduce the dust generated compared with the use of cutting wheels. The tool is not cheap, but has been reported to justify the purchase price rapidly by the increased speed of work and reduced site cleaning costs.)

At concrete recycling plants water spray dust suppression was used, but it was acknowledged that it was better to eliminate the need for an attendant to work at a dusty location. This could be achieved by ensuring suitable feedstock, i.e. by rigorously separating out materials that would have needed to be retrieved from the crusher at a dusty stage of the process, a "modification" that had been introduced and apparently found to be successful.

During tunnelling water dust-suppression on drills was seen to be effective. Respirable dust and RCS exposures were considered unlikely to approach WELs. Shotcreting could be required over a period sufficiently long that the WEL for respirable particulate would be exceeded and RCS exposure might also exceed the (new) WEL. Ventilation of the worksite by the standard tunnelling arrangement disperses aerosols from shotcreting or contaminants from other work to the rest of tunnel (which breaches basic occupational hygiene principle of negative pressure extraction.)

The correlation between the measurements of RCS exposure considered during the RCS and the observed engineered controls at the sites are summarised in the table below:

Table 4 Construction task RCS exposures and controls applied

WEL exceeded during site measurements	
Description::	**Comment:**
Site C3 Grit-blasting sandstone building	Dry blasting selected
Site C4 Grit-blasting brick walls ands paviours	Dry blasting selected
Site C5 disc cutter removal of mortar	Ineffective attempt to extract dust
Site C6 disc cutter removal of mortar	Ineffective attempt to improve capture of dust
Site C7 Recycling concrete	Inadequate water spray dust suppression
Site C9 Tunnelling – shotcreting	No suppression applied
WEL not exceeded during site measurements	
Site C1 concrete paving slab and kerb replacement	Water suppression used during cutting
Site C2 granite paving slab and kerb installation	Water suppression used during cutting
Site C8 Recycling concrete	Inputs restricted to remove need for dusty work
Site C9 Tunnelling – drilling	Water dust suppression installed

5 CONCLUSIONS

Many activities in construction are capable of generating dust and RCS concentrations considerably above WELs, and possibly to a greater extent as higher-powered tools develop.

Employers have underestimated the extent of exposures, and in many cases have not made the implementation of exposure control a priority (when judged by assessment of "control competence.")

Assessment of "control competence," i.e. the robustness of the systems underpinning the effectiveness of engineered exposure controls or Respiratory Protective Equipment, suggests that employers who have made assessments are likely to achieve effective ongoing exposure control, those who have not are not likely to maintain control.

Adoption of engineered controls as standard would in most cases reduce exposures to within WELs. Conversely, where controls are not applied to many tasks (e.g. dry grit-blasting buildings or cutting out mortar without effective on-tool extraction) exposures can greatly exceed WELs.

RPE competency is not adequate to ensure reliable protection when engineered controls are not applied.

Where high-value plant has been introduced (e.g. rock-drilling machines in tunnelling, crushers at recycling plants) dust suppression measures are more likely to have been installed than where small items of plant are in use.

6 APPENDICES

APPENDIX A TABLES

Table 1: ‘Silica in Construction’: Summary table of employee exposure to RCS for construction activities from report of TDS – Silica In Construction: Northage & Heathfield 1995)

Table 2: Data from HSE questionnaire on respirable crystalline silica - Exposure to RCS in the construction sector.

Table 3: Data from ONS summary of employment statistics, 2005 – local units by employment size band

Table 4: Data from ONS summary of employment statistics, 2005 – “VAT-based enterprises” by employment size band

Table 5: Data from ONS summary of employment statistics, 2005 – VAT-based enterprises by turnover size band

Table 6 Table 6 Summary of SBS Data :Construction Sector

Table 1: 'Silica in Construction': Summary table of employee exposure to RCS for construction activities from report of TDS – Silica In Construction: Northage & Heathfield 1995)

Activity	Total No. of workers surveyed	Geometric mean ($mg.m^{-3}$)	Minimum exposure ($mg.m^{-3}$)	Maximum exposure ($mg.m^{-3}$)	Activity generating maximum exposure
Bridge repairs	8	0.04	0.02	0.1	Cutting of granite for 15min period using powered steel saw (<5000 rpm)
Building repairs	2	0.3	0.2	0.5	Cutting of concrete in car park using pneumatic cutter.
Channelling cement	2	0.96	0.93	1.0	Channelling using petrol driven saw (< 5000rpm)
Polishing terrazzo tiles	1	-	N/D	N/D	Dry grinding & polishing of floor surface with 2% free silica produced no detectable levels.
Tunnelling	5	0.4	0.03	7.6	Shotcreting & roadheader operations. Degree of exposure is significantly affected by silica content of rock being tunnelled.
Roadway repairs	1	0.05	0.05	0.05	Repair of concrete pillars using power tools. Concentration over work period (43mins) was $0.6mg/m^3$

Table 2: Data from HSE questionnaire on respirable crystalline silica - Exposure to RCS in the construction sector*.

Construction sector reply no	Category: S (<50) M (<250) L (>250)	No of workers (UK)	No employees exposed to RCS	No of employees exposed to RCS above 0.3 $mg.m^{-3}$	No of employees exposed to RCS above 0.1 $mg.m^{-3}$	No of employees exposed to RCS above 0.05 $mg.m^{-3}$	No of employees exposed to RCS above 0.01 $mg.m^{-3}$	Comments
1	S	28	0	N/a	N/a	N/a	N/a	
2	L	3500	0	N/a	N/a	N/a	N/a	4 companies
3	L	5000	0	N/a	N/a	N/a	N/a	4 companies
4	L	N/s	750	0	0	750	750	
5	L	N/s	0	N/a	N/a	N/a	N/a	House building
Total		8528	750 (8.8%)	0 (0%)	0 (0%)	750 (8.8%)	750 (8.8%)	

Note: *- Only 5 replies were received from this sector.

Table 3: Data from ONS summary of employment statistics, 2005 – local units by employment size band (from table A2.1)

Activity: Division 45, Construction**:**	**Employment size band:**								
	0 - 4	**5 - 9**	**10 - 19**	**20 - 49**	**50 - 99**	**100 - 249**	**250 –499**	**500+**	**Total**
Number of local units	**155,620**	**21,330**	**10,830**	**6,655**	**1,995**	**1,095**	**375**	**85**	**197,855**
percentage	78.7%	10.8%	5.5%	3.4%	1.0%	0.6%	0.2%	0.0%	
Cumulative percentage	**78.7%**	**89.4%**	**94.9%**	**98.3%**	**99.3%**	**99.8%**	**100.0%**	**100.1%**	
Notional size	2	7	15	35	75	175	325	510	
Derived Employment numbers:	311,240	149,310	162,450	232,925	149,625	191,625	121,875	43,350	1,362,400

Table 4: Data from ONS summary of employment statistics, 2005 – “VAT-based enterprises” by employment size band (from table B4.1)

Activity: Division 45, Construction**:**	**Employment size band:**									
	0 - 4	**5 - 9**	**10 - 19**	**20 - 49**	**50 - 99**	**100 - 249**	**250 –499**	**500 –999**	**1000+**	**Total**
Number of local units	**152,715**	**19,900**	**9,445**	**5,280**	**1,165**	**605**	**165**	**75**	**70**	**189420**
percentage	80.6%	10.5%	5.0%	2.8%	0.6%	0.3%	0.1%	0.0%	0.0%	
Cumulative percentage	**80.6%**	**91.1%**	**96.1%**	**98.9%**	**99.5%**	**99.8%**	**99.9%**	**100.0%**	**100.0%**	
Notional size	2	7	15	35	75	175	325	750	1010	
Derived Employment numbers:	305,430	139,300	141,675	184,800	87,375	105,875	53,625	56,250	70,700	1,074,330

Table 5: Data from ONS summary of employment statistics, 2005 – VAT-based enterprises by turnover size band (from table B5.1)

Activity	Turnover size (£ thousand):									
	0-49	**50-99**	**100-249**	**250-499**	**500-999**	**1,000-1,999**	**2,000-4,999**	**5,000-9,999**	**10,000-49,999**	**50,000+**	**Total**
Division 45, Construction	27,485	54,990	52,490	23,375	15,000	8,245	5,135	1,575	1,150	245	189,695
percentage	14.5	29.0	27.7	12.3	7.9	4.3	2.7	0.8	0.6	0.1	
Cumulative percentage	14.5	43.5	71.1	83.5	91.4	95.7	98.4	99.3	99.9	100	

Table 6 Summary of SBS Data: Construction Sector

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 $mg.m^{-3}$	0.3>x≥0.1 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Exposure above 4 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Control	RPE	
C1	B	RPE, W	4	1	0	0	0.05	0	1.19	4	2	Aggregate, concrete slabs
C2	B	RPE	6	2	0	0	0.021	0	0.296	3	N/A	Granite slabs, Concrete Kerbs
C3	D	RPE	2	2	1	0	0.717	1	44.08	2	2	Non-silica abrasive, sandstone
C4	D	PPE	2	0	0	0	0.069	1	8.09	2	2	Facing bricks, paviours, non-silica abrasive
C5	C	RPE, LEV	3	0	0	1	0.14	1	2.79	2	2	Sand and cement mortar
C6	C	RPE, LEV	1	0	0	1	0.22	1	2.25	2	2	Sand and cement mortar
C7	A	W, RPE	2	0	0	1	0.118	0	0.35	4	2	Recycling concrete
C8	A		4	0	0	0	0.03	0	0.314	4	N/A	
C9a	E	W	2	1	0	0	<0.01	0	0.2			Drilling medium- silica schist
C9b	E		3				0.07	0	1.5			Shotcreting
Totals:			**29**	**6**	**1**	**3**		**4**				
Percentages:					**3%**	**10%**		**14%**				

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of building surfaces using (non-silica) abrasives. E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation, LEV = Local exhaust ventilation

APPENDIX B SURVEY VISIT SUMMARY REPORTS

Silica Baseline Survey – Summary Reports

The following pages contain Summary Reports for the visits made to the various **Construction sites** included in the baseline survey.

Although the reports have been anonymised, descriptions of the operations undertaken and the exposure control measures at each site are provided.

Silica Baseline Survey – Survey visit summary reports

Site 1

Description of Facility / Operations

The Derbyshire County Council (DCC) workers were commissioned to undertake the installation of tactile paving strips at the street corners of various roads in the city of Chesterfield.

The tactile paving work is undertaken by a team of two DCC employees. The materials and equipment are brought to site on a flat-back truck and include paving slabs, kerbstones, C20 cement and portable angle grinder.

The work begins by filling the work area with the required amount of C20 cement in order to achieve a firm level surface on which to lay the kerbs and paving. The C20 is shovelled from the back of the truck into a wheelbarrow, however at this stage the C20 is still damp and does not liberate any significant amount of dust when handled.

The kerbstones are then installed and in order to achieve the required fit several of them may require cutting down to size. Similarly when the paving slabs are installed some of these will also require cutting.

The cutting is done on the pavement next to the truck using a portable angle grinder fitted with a 14inch blade. The cutting of each of the kerbs or paving stones only takes a short duration (typically 10-60 seconds) and during work on a strip of tactile paving at any one street corner some 25-35 cuts might be required to achieve the required fit. Normally no more than three street corner strips of tactile paving are installed during a days shift. This means that workers might potentially spend a total of up to 100 minutes per day cutting. The actual duration is more realistically likely to be in the region of 45 minutes.

Materials

- Aggregates (C20 cement)
- Cement kerbs and paving slabs (typical silica content 12-40%).

Control Measures

The disc cutter is fitted with a water feed system which is designed to suppress the dust generated and cool the saw blade. The water is fed to the blade using a manually pumped pressure system via a hose from a small storage tank (approximately 20 litres). When the pressure in the vessel falls it is necessary for one of the workers to manually pump up the pressure so that it continues to be fed to the blade. Occasionally some of the cutting work can require only small sections of the paving slabs to be removed and sometimes these cuts cannot be made effectively with the water feed in place. The water and slurry can run down over the slab and prevent the worker from clearly seeing the cutting line he needs to follow.

During the study the workers performed the cutting of a paving slab with and without the water feed system active for visual comparisons purposes. The amount of dust generated during the cutting work was significantly reduced when the water feed system was active.

Whilst undertaking their work the operatives wore long trousers, hi-vis vests and safety gloves and footwear (all mandatory). Specific PPE worn during cutting works were P2 disposable respirators, safety goggles and hearing defenders. New disposable respirators were available for each days work.

Control competency rating (0 - 5)	**4 –** See Appendix D for descriptors
RPE competency rating (0 – 5)	**2 –** See Appendix D for descriptors

Notes:

Control Competency:

Dry cutting is the principal source of exposure to dust (RCS) at the sites. Based on inspection of engineering controls and supporting exposure measurement data it is apparent that control of exposure is satisfactory. Risk assessments are conducted by management prior to work but were not held by operatives on site during operations.

RPE Competency:

- Face fit testing not conducted. Regulation 7 of COSHH states that the initial selection of RPE (full / half face including disposables) should include fit testing to ensure that the correct device has been chosen (in terms of size / fit etc.). Limited evidence of selection process, no face fit testing. Training in use of RPE provided. No assessment of residual risk.

Table of Results

Sample No	Sample type	Sample Position	Duration, Mins	Exposures, mg.m^{-3}			
				RCS		Respirable dust	
				Task	8-hr TWA	Task	8-hr TWA
Day 1							
1	SL	Positioned on works vehicle next to operations (<2m away)	184	0.09	-	0.5	-
2	PL	NW – Cutting and laying of tactile paving slabs and kerb stones	183	0.14	0.054	0.95	1.19
3	PL	AW – Laying of aggregates and minor cutting works	182	0.03	0.011	0.23	0.28
Day 2							
4	PL	NW – Cutting and laying of tactile paving slabs and kerb stones	121	<0.04	0.01	0.13	0.16
5	PL	AW – Laying of aggregates and minor cutting works.	119	<0.04	0.01	0.15	0.19

Summary of results:

Samples were taken over two days. All the results from this study were below the recently revised WEL for respirable crystalline silica (0.1 $mg.m^{-3}$ 8hr TWA).

The highest results came from the worker who performed the majority of the kerb / paving slab cutting works using hand held power tools (0.054 $mg.m^{-3}$ 8 hr TWA). It should be noted that this result covered a small amount of dry cutting work done to demonstrate the difference in the dust levels generated with & without the water suppression active. On the following day, when the water suppression was active for the duration of this sampling period, this operative's result was lower (0.01 $mg.m^{-3}$ 8 hr TWA). On both days of the survey the weather was sunny and fine with a slight breeze (<10mph) that aided the dispersion of any dust generated during the work. On days when there is negligible wind dust exposures may be higher.

<u>Site data transferred to summary:</u>

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 $mg.m^{-3}$	0.3>x≥0.1 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Exposure above 4 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Control	RPE	
C1	B	RPE, W	4	1	0	0	0.05	0	1.19	4	2	Aggregate, concrete slabs

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of surfaces (buildings) using (non-silica) abrasives., E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation, LEV = Local exhaust ventilation

Site 2

Description of Facility / Operations

The company were commissioned to undertake renovation works at a public square in the town of Luton. This work included the laying of Type 1 aggregates followed by the installation of granite paving slabs & stones.
Type 1 aggregates were laid in order to achieve a firm level sub-base on which to lay the paving slabs & stones. The laying of the aggregates was done by two operatives, one operated a tipper truck and the second spread the aggregates manually.

The stone & slab cutting was undertaken by two operatives. The equipment used for the cutting was a portable cut-off saw and a stationary circular saw. Both saws had been hired for the duration of this phase of the works from a tool hire company. Both saws were fitted with water feed systems designed to keep the blade cool and also to reduce the levels of dust typically generated when dry cutting stonework.

The cutting of any of the stones and slabs only takes a short duration (typically 10-60 seconds). The amount of cutting required is dependent on the nature of the project, in this instance the cutting of stones was done mainly on the first day and slabs were cut during the second day. The cutting of either a stone or slab was required every few minutes during the morning of each shift, much less cutting was required in the afternoons.

Material

Aggregate (Type 1)
This is usually a crushed rock, typically limestone, granite or gritstone, although it may be slag or some other inert hard material.

Concrete Kerbstones
“Granite” paving slabs imported from China, (typical silica content 12-40%).
Control Measures

Both saws, stationary and portable, were fitted with water feed systems which are designed to suppress the dust generated and cool the saw blade. The water is fed to the blade of the portable saw using a manually pumped pressure system via a hose from a small storage tank (approximately 20 litres). When the pressure in the vessel falls it is necessary for one of the workers to manually pump up the pressure so that it continues to be fed to the blade.

Whilst undertaking their work the operatives wore long trousers, hi-vis vests and safety gloves and footwear (all mandatory). Specific PPE worn during cutting works were safety goggles and hearing defenders. It should be noted that operatives occasionally chose not make use of the hearing and eye protection provided during cutting operations.

No RPE was worn by the operatives as it was considered, following risk assessment, that the duration of the work and the existing control measures (water suppression) offered a sufficient level of control of the dust generated.

Control competency rating (0 - 5)	**3 –** See Appendix D for descriptors
RPE competency rating (0 – 5)	**N/A –** See Appendix D for descriptors

Notes:

Control Competency:

Stone cutting & aggregate laying are the principal source of exposure to dust (RCS) at the various sites where the company undertake this type of work. Based on inspection of engineering controls and supporting exposure measurement data it is apparent that on the day of the survey control of exposure was satisfactory.

RPE Competency:

Operatives were not provided with RPE for the operations included within the scope of this study. Based on the results of this survey, RPE would not appear to be essential in order to satisfactorily control exposure.

Table of Results

Sample No	Sample type	Sample Position	Duration, Mins	Exposures, mg.m^{-3}			
				RCS		Respirable dust	
				Task	8-hr TWA	Task	8-hr TWA
1	PL	DS – Stone cutting	160	0.03	0.010	0.168	0.056
2	PL	GS – Stone cutting	150	0.06	0.019	0.425	0.133
3	SL	Static – Aprrox 2m from stone cutting machine.	246	<0.02	-	0.041	
4	PL	SS – Aggregate laying	181	0.03	0.011	0.427	0.161
5	PL	KS – Aggregate laying	170	0.06	0.021	0.835	0.296
6	PL	GS – Stone cutting	279	<0.02	0.012	0.232	0.135
7	PL	DS – Stone cutting	274	<0.02	0.011	0.103	0.059
8	SL	Static – Approx 3m from stone cutting machine	321	0.02	-	0.060	

Summary of results:

Samples were taken over two days. All the results from this study were below the recently revised WEL for respirable crystalline silica (0.1 mg/m3 8hr TWA).

In total six personal samples were taken and the 8hr TWA's for these ranged from 0.010 - 0.021mg/m3. The highest results came from the worker who performed the manual shovelling of the aggregates once they had been dumped from the tipper truck (0.021mg/m3 8hr TWA).

On both days of the survey the weather was dry but overcast with a slight breeze (<5mph) that aided the dispersion of any dust generated during the work. On days when there is negligible wind dust exposures may be higher.

It should be noted that Type 1 aggregates can be prepared using a variety of stones including recycled concrete materials. The varied nature of the composition material of the aggregates means that the RCS content of the aggregates supplied may vary. This should be considered when assessing the risk of exposure to RCS posed by the use of such materials.

Site data transferred to summary:

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 $mg.m^{-3}$	0.3>x≥0.1 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Exposure above 4 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Control	RPE	
C2	B	RPE	6	2	0	0	0.021	0	0.296	3	N/A	Granite slabs, Concrete Kerbs

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of surfaces (buildings) using (non-silica) abrasives., E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation, LEV = Local exhaust ventilation

Site 3

Description of Facility / Operations

A specialist contractor was commissioned to undertake the blast cleaning of the external sandstone surfaces of a building in the town of Halifax on behalf of a building restoration company. The client requested this work as the building was under going major refurbishment work and it was deemed necessary to remove the dirt and discolouration that had accumulated on the external stonework.

The external stonework had numerous hand carved features which would have lead to the accumulation of slurry had wet blast cleaning methods been employed. It was therefore decided that in this instance dry blasting would be performed.

The blast cleaning was done using an abrasive called RotoSoft produced by Weinburger Ltd. This material is aluminium silicate propellant flour with a typical particle size range of 0.09 – 0.25 mm. The material is loaded manually ("rip & tip") from 25kg bags by the second operative (pot-man) into the blast hopper. It is then pressure fed to the blast nozzle where it is blasted directly against the sandstone surface. The material is blasted against the sandstone at a suitable pressure that will ensure the desired removal of surface residue without damaging the stone significantly. After the surface residue has been removed this material and the dislodged sandstone particles from the stones surface become airborne and may be inhaled by the workers or any persons in the immediate vicinity.

The blast hopper requires refilling after every 30-40 minutes of blasting. During the actual blasting the second operative generally remains a 'safe' distance away from the works observing and waits any call for assistance from the blast operative.

The level of dust generated during the work was significant and, as a result of the windy conditions, this airborne material was blown away from the work area and down the street. Had the work been undertaken on a clam day with less wind to disperse the dust then exposures may have been greater.

The duration of the blasting work is dependent on the size of the area to be cleaned. The building being cleaned during this study was being done over the course of two consecutive Sundays. Blasting work was conducted for approximately 4-5 hours on the day of the study.

Material

Abrasive – Rotosoft (Glaspudermehl) 25kg bags, aluminium silicate propellant flour with a typical particle size range of 0.09 – 0.25mm. RCS is not contained within raw material but is generated by the blasting of product against silica-containing stone
Sandstone substrate, typically >70% silica content

Control Measures

The principal control measure employed during blasting is the use of water. When the abrasive is suspended in water and then applied to the building the amount of dust that becomes airborne is significantly reduced. For reasons previously mentioned this was not employed during thie work on this day..

The blast operative used constant flow airline breathing apparatus (BA) with a blasting helmet (Nova 2000 model) to reduce his exposure to the dust generated during his work. This equipment has a protection factor of 40.
Whilst undertaking their work the operatives wore normal work clothing and safety footwear. Operatives also wore hearing defenders during the blasting.

Control competency rating (0 - 5)	**2 –** See Appendix D for descriptors
RPE competency rating (0 – 5)	**2 –** See Appendix D for descriptors

Notes:

Control Competency:

Over-exposures occurred to blast operative, little understanding of exposures and adequacy of controls. Main Contractor has generic risk assessment for blasting operations, but not passed to subcontractor, who had not prepared one of his own either. Risk assessment not held on site during survey.

RPE Competency:

Evidence of provision of suitable and adequate equipment but strong evidence of poor practices in use. No evidence of adequate storage. No assessment of residual risk. Compressed air quality independently checked by contractor.

Table of Results

Sample No	Sample type	Sample Position	Duration, Mins	Exposures, $mg.m^{-3}$			
				RCS		Respirable dust	
				Task	8-hr TWA	Task	8-hr TWA
1	PL	MG – Dry blasting work.	280	1.22	0.717	75.035	44.083
2	PL	GD – Pot man, non-blasting activities.	268	0.04	0.04	0.465	0.465
3	SL	Static – On generator beneath works area.	265	0.05	-	0.261	-
4	SL	Static – Within 1st floor room behind blasting area.	137	1.27	-	15.460	-

Summary of results:

The results of the measurements taken from the blasting operative were above the recently revised WEL for respirable crystalline silica (0.1 $mg.m^{-3}$ 8hr TWA). The highest exposure, taken from the blasting operative, was 0.717 $mg.m^{-3}$ 8hr TWA. The result taken from the pot man was below the WEL, 0.04 $mg.m^{-3}$ 8hr TWA. Additionally the results from blasting operative also exceeded the occupational exposure limit for respirable dust (4 $mg.m^{-3}$ 8hr TWA).

It should be noted that the levels of exposure to RCS during this type of dry blasting work is likely to be dependent on the nature of the stone being cleaned. During this study blasting work was being conducted on a sandstone building. Sandstone is a high silica content stone (typically >70% silica) and similar work on stonework with a lower silica content (e.g. marble or limestone) is likely to result in lower exposures to RCS.

It should also be noted that when performing outdoor work that generates dust the severity of the hazard may be affected by prevailing weather conditions. Wet weather and / or wind may result in lower potential exposures. The level of dust generated during the survey was significant and, as a result of the windy conditions, this airborne material was blown away from the work area and down the street. Had the work been undertaken on a clam day, with less wind to disperse the dust, then exposures may have been greater.

Site data transferred to summary:

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 $mg.m^{-3}$	0.3>x≥0.1 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Exposure above 4 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Control	RPE	
C3	D	RPE	2	2	1	0	0.717	1	44.08	2	2	Non-silica abrasive, sandstone

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of surfaces (buildings) using (non-silica) abrasives., E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation, LEV = Local exhaust ventilation

Site 4

Description of Facility / Operations

The company were employed to remove moss etc. from the steps and walkways and clean staining and discolouration from some walls of a recent brick building. The company would normally have undertaken the work by washing with high-pressure water. However, due to a hosepipe ban in the area at the time, they had decided to employ dry grit-blasting. The working pressure was selected to be as low as possible to minimise the damage done to the surfaces.

The work is necessarily peripatetic, and is therefore done using a van as a mobile store and office.

Material

The abrasive used was "Calcium silicate - SC" supplied by Wolverhampton Abrasives Ltd, an IMI company of Orgreave Drive, Sheffield. It is described as an amorphous granular glassy material formed principally of the fused oxides of silicon, calcium and aluminium, with no other compound present above 0.15% by weight. It would seem to be typical of rapidly-cooled slag produced from metal smelting.

The substrates being worked on were modern bricks and "brick" paviours. The amount of silica available that could be released to the air would have been a function of the surface composition of these materials: brick clays contain silica and bricks are frequently faced with sand and pigment for decorative effect: concrete paviours incorporate a high proportion of silica aggregate.

Control Measures

The principal control when pressure-jetting would normally be the water which would be used either to propel or in lieu of the abrasive. Dry-blasting inevitably generates mobile fine particulate and demands a high level of respiratory protection. A blasting hood to the EN271 Standard fed with a constant flow of clean compressed breathing air was used by the blasting operator, providing adequate protection.

Blasting equipment is available (at a price) that incorporates vacuum recovery of both grit and debris. This would be an effective way of both controlling exposure by capturing the contaminant at source and of minimising contamination spread.

The blasting attendant used a disposable filtering facemask and, in the light of the exposures measured at the site, the lowest level of filtration would have given adequate protection.

Control competency rating (0 - 5)	**3 –** See Appendix D for descriptors
RPE competency rating (0 – 5)	**2 –** See Appendix D for descriptors

Notes:

Control Competency:
Occasional over-exposure. Generic COSHH assessment for stone work held by management, no copy held by site operatives. Reasonable awareness of hazard and risk and desire to improve.

RPE Competency:
Evidence of provision of suitable and adequate equipment but strong evidence of poor practices in use. No evidence of adequate storage. No assessment of residual risk. Compressed air quality independently checked by contractor.

Monitoring results.

The results of the site measurements are shown in the table below.

Operative/ Area Sampled	**Sample duration (mins)**	**Respirable Crystalline Silica ($mg.m^{-3}$)**		**Respirable dust ($mg.m^{-3}$)**	
		Task measurement	8-hr TWA	Task measurement	8-hr TWA
Dry blasting Operative	208	18.66	8.09	0.16	0.069
Pot man, non-blasting activities.	208	2.29	0.99	0.04	0.017

Both workers were therefore adequately protected by their RPE. It was recognised that the work method was not optimal but the risk assessment should have acknowledged the attendant's potential exposure in less favourable conditions.

Site data transferred to summary:

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 $mg.m^{-3}$	0.3>x≥0.1 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Exposure above 4 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Control	RPE	
C4	D	PPE	2	0	0	0	0.069	1	8.09	2	2	Facing bricks, paviours, non-silica abrasive

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of surfaces (buildings) using (non-silica) abrasives., E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation, LEV = Local exhaust ventilation

Sites 5& 6

Description of Facility / Operations

The company appoints licensees to use their name after training on the patented mortar-pumping equipment. The licensees operate as independent companies and typically offer services such as repointing brick and stonework, replacing bricks, weatherproofing structures, performing epoxy crack repairs and deep pressure pointing and grouting. Most work is undertaken on Local Authority or Housing Association buildings and is therefore performed “in the field.”

The company arranged visits to two of their licensees, working on sites in Nottingham and Stoke-on-Trent.

The preparation for repointing involves the removal of old mortar, generally performed using hand-held electric grinding tools with rotating abrasive blades. Hammer drills are used for some areas where cutting wheels are not suitable.

Material

The mortar to be removed will contain a variable proportion of silica dependent upon the original mix. However sand and cement form the basis of most mortar mixes and silica will therefore form the greater proportion of most of the material to be removed.

Control Measures

Repointing work is reported to be included in the risk assessments produced as part of method statements (which are required to be produced although they were not held by operatives on site during operations. Silica exposure had not been addressed, however.

The cutting wheels are housed in guards that act as capture hoods and which have adjustable extensions to optimise their performance. The hoods are connected by flexible tubing to vacuum cleaners fitted with HEPA filters. Gun-point have recently been trialling new capture hoods produced for them by a metal fabricator. The new hoods were being used at the Nottingham site during this study but were not used at the Stoke site

The operatives have been trained to pull the blade across the mortar in the direction of the blade rotation as this has been found to generate considerably less dust.

Specific PPE worn during cutting works were P3 ori-nasal (half face) respirators, safety goggles and hearing defenders. New filters for the workers respirators were kept in the van on site. No face fit testing had been undertaken for the RPE.

Control competency rating (0 - 5)	**2** – See Appendix D for descriptors
RPE competency rating (0 – 5)	**2** – See Appendix D for descriptors

Notes:

Control Competency: Dry grinding of mortar is the principal source of exposure to dust (RCS) during the operations. Based on inspection of engineering controls and supporting exposure measurement data it is apparent that RCS exposures exceeding the WEL occur frequently.

Risk assessments as part of method statements submitted as part of contract tenders prior to work but were not held by operatives on site during operations. Risk assessments relating to silica exposure not performed.

RPE Competency: - Face fit testing not conducted. Regulation 7 of COSHH states that the initial selection of RPE (full / half face including disposables) should include fit testing to ensure that the correct device has been chosen (in terms of size / fit etc.). Limited evidence of selection process, no face fit testing. No evidence of adequate training. No assessment of residual risk.

Table of Results

Sample No	Sample type	Sample Position	Duration, Mins	Exposures, $mg.m^{-3}$			
				RCS		Respirable dust	
				Task	8-hr TWA	Task	8-hr TWA
Site 5:	Modified blade covers/captor hoods in use						
1	PL	NH – Mortar removal using power tool	177	0.22	0.08	2.783	1.026
2	PL	FW – Mortar removal using power tool	188	>0.36	0.14	6.93	2.71
Site 6:	Original blade covers in use						
3	PL	M – Mortar removal using power tool	162	0.03	0.01	0.16	0.05
4	PL	GB – Mortar removal using power tool	347	>0.3	0.22	3.11	2.25

Summary of results:

Monitoring in two locations revealed exposure to RCS at both during mortar removal with power tools. At the first site respirable dust exposures ranged from 0.16 to 6.9 $mg.m^{-3}$ and RCS exposures were 0.01 to 0.14 $mg.m^{-3}$ (all 8-hr TWA.) The one measurement showing low exposures was thought to result from work on a side of the house exposed to the wind. At the second site a sample of nearly 6 hours duration showed an 8-hr TWA respirable dust exposure of 3.1 $mg.m^{-3}$ and RCS exposure of 0.22 $mg.m^{-3}$.

Cutting wheel guards modified to improve their performance were being tested at the first site: notwithstanding the modification one employee had task-based respirable dust exposure more than twice that experienced by the user of the unmodified hood.

Site data transferred to summary:

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 mg.m^{-3}	0.3>x≥0.1 mg.m^{-3}	Highest exposure mg.m^{-3}	Exposure above 4 mg.m^{-3}	Highest exposure mg.m^{-3}	Control	RPE	
C5	C	RPE, LEV	3	0	0	1	0.14	1	2.79	2	2	Sand and cement mortar
C6	C	RPE, LEV	1	0	0	1	0.22	1	2.25	2	2	Sand and cement mortar

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of surfaces (buildings) using (non-silica) abrasives., E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation, LEV = Local exhaust ventilation

Sites 7 & 8

Description of Facility / Operations

The sites process demolition rubble to produce material for use as fill.

All material is delivered by lorries. Varying grades or types of demolition rubble are stockpiled around the site. The crusher is a mobile tracked vehicle, and is moved around the site to suit operations.

Rubble is fed into a hopper at one end of the crusher by a large digger, causing the release of airborne dust, although all of the actual crushing machinery is enclosed during operation. The hopper slopes and vibrates, causing the rubble to fall into the metal jaws of the crusher. The crushed material is discharged via an upwardly sloping conveyor several metres in length and as it falls from this conveyor a significant amount of airborne dust is released. The processed material is then removed by a large digger and stockpiled on the site to await export.

When type-1 material is produced the crusher output is screened to remove particles >100mm diameter. These are fed back into the crusher and the further processing would generate a different pattern of dust generation to that during the brick and concrete crushing performed on the day of the survey in Leeds.

The above operations are typically carried out by a team of three operators. One man drives the digger which loads the crusher. On the day of the visit to Leeds, a cab window was permanently open on this vehicle. A second worker operates the crusher. This involves him standing continuously on top of the machine during crushing, adjacent to the feed hopper. From this position he is able to operate the machines controls and also remove any unwanted debris from the feed hopper using hand-held tongs, as the rubble proceeds down the feed hopper into the crusher's jaws. (This task has been almost eliminated at Liverpool site by rigorous control of incoming material.) On the day of the Leeds visit, the third operator drove a large earth moving type vehicle, which was used to remove the crushed material away to a stockpile. Under the more normal situation of crushing 'Type 1' material, this individual would operate the screening machine.

Material

The principal input is demolition rubble. This is mainly a mixture of road planings and concrete but may be a mixture of bricks (with mortar) and concrete. Glass unfit for remelting is also processed (but will have no crystalline silica content.)

Control Measures

The crushing machine at site A is fitted with three main spray bars to provide water-mist dust suppression which operates continuously during crushing. A 'drench shower' is also provided above the discharge conveyor and can be used on particularly dry days to damp down dust from the crushed material. A further dust-suppression measure is a water spray which may be applied to the stockpile of debris being fed into the crusher.

At site B quality control of the incoming material is used to eliminate so far as is practicable the need for an operative to work "supervising" the crusher input (thereby minimising the time spent in an area where dust is released)

General ventilation is entirely dependant upon prevailing weather conditions. On the day of the visit there was a stiff breeze blowing continuously, which effectively dispersed the dust clouds formed from loading the crusher feed hopper and from the crushed material as it falls from the conveyor at the end of the crushing.

Table of Results

Summary of results:

Respirable dust exposure ranged from below the limit of detection to 0.47 $mg.m^{-3}$ 8-hour TWA, and task-based measurements were comparable at both sites. The RCS measurements were much lower at site B where procedures had been changed, and the highest 8-hr TWA exposures (even with a worst-case estimate of 9 hours exposure in a day) was no more than half of the measurement at site A.)

Site A Sample No	**Sample type**	**Sample Position**	**Duration, Mins**	**Exposures, $mg.m^{-3}$**			
				RCS		**Respirable dust**	
				Task	**8-hr TWA**	**Task**	**8-hr TWA**
1.	PL	I – crusher operator	244	0.118	0.06	0.35	0.18
2.	PL	BH – digger driver, loading crusher	283	ND	ND	ND	ND
Site B – after procedures upgraded							
269		CS, machine operative	175	<0.017	<0.02	0.27	0.31
270		RB, Unit manager	343	0.030	0.03	0.42	0.47
271		AK, Excavator operator	368	<0.012	<0.01	0.33	0.37
274		JT, Excavator driver	93	<0.019	<0.02	0.28	0.32

Site data transferred to summary:

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 $mg.m^{-3}$	0.3>x≥0.1 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Exposure above 4 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Control	RPE	
C7	A	W, RPE	2	0	0	1	0.118	0	0.35	4	2	
C8	A		4	0	0	0	0.03	0	0.47	4	N/A	

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of surfaces (buildings) using (non-silica) abrasives., E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation, LEV = Local exhaust ventilation

Site 9

Description of Facility / Operations

The site was visited specifically to obtain exposure data for the SBS. Drilling and Blasting were being performed, also "shotcreting" by which wet concrete is applied to the tunnel walls & roof by gun. The Tunnel boring machine was inoperative on the day so exposure could not be assessed.

Material

Tunnelling: Boring schist, (metamorphosed hard rock, banded with quartz to a variable extent, here reported as low- to medium silica.)

Shotcreting: gun application of fine-aggregate concrete.

Control Measures

Wet-suppression built into drill rig (but topless cab for reduced clearance) Shotcreting machine designed for remote control, but operator has to stand close by.

Clean air is supplied to worksite, but discharged up to 50 metres from the working face (n.b. contaminants are flushed back along the tunnel)

Table of Results

***Estimated exposures calculated from task-based measurements**			
		Activity:	
Substance	**Exposure pattern**	**DRILLING**	**SHOTCRETING**
Respirable dust	1/shift	0.2 mg/m^3	1.5 mg/m^3
	4/shift	improbable	5 mg/m^3
Respirable crystalline silica	1/shift	<0.01 mg/m^3	0.02 mg/m^3
	4/shift	improbable	0.07 mg/m^3

Notes on Table 1: Exposure Pattern of 1 per shift relates to one block of the measured activity as sampled. 4/shift refers to effect of 4 blocks of that activity.

Summary of results:

Drilling – dust suppression effective

Shotcreting- poor control (particulate generated.) WEL for Respirable Particulate likely to be exceeded if activity performed >4 hrs / shift.

Also ventilation air supplied at face, purging contaminants there but causing exposures remote from worksite.

Site data transferred to summary:

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 $mg.m^{-3}$	0.3>x≥0.1 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Exposure above 4 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Control	RPE	
C9	E	W	2	1	0	0	<0.01	0	0.2			Drilling Medium- silica schist
C9	E		3				0.07	0	1.5			shotcreting

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of surfaces (buildings) using (non-silica) abrasives., E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation,

Summary table of SBS data: Construction sector

Site	Activities	Control strategy	Samples collected		Number of measurements (8-hr TWAs)					Competency Descriptor Ratings		Material type
					RCS			Respirable Dust				
			Personal	Static	≥0.3 $mg.m^{-3}$	0.3>x≥0.1 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Exposure above 4 $mg.m^{-3}$	Highest exposure $mg.m^{-3}$	Control	RPE	
C1	B	RPE, W	4	1	0	0	0.05	0	1.19	4	2	Aggregate, concrete slabs
C2	B	RPE	6	2	0	0	0.021	0	0.296	3	N/A	Granite slabs, Concrete Kerbs
C3	D	RPE	2	2	1	1	0.717	1	44.08	2	2	Non-silica abrasive, sandstone
C4	D	PPE	2	0	0	0	0.069	1	8.09	2	2	Facing bricks, paviours, non-silica abrasive
C5	C	RPE, LEV	3	0	0	1	0.14	1	2.79	2	2	Sand and cement mortar
C6	C	RPE, LEV	1	0	0	1	0.22	1	2.25	2	2	Sand and cement mortar
C7	A	W, RPE	2	0	0	1	0.118	0	0.35	4	2	Recycling concrete
C8	A		4	0	0	0	0.03	0	0.47	4	N/A	
C9	E	W	2	1	0	0	<0.01	0	0.2			Drilling Medium- silica schist
C9	E		3				0.07	0	1.5			shotcreting
Totals:			**29**	**6**	**1**	**4**		**4**				
Percentages:					**3**	**14**		**14**				

Activity: A: Movement, crushing, screening of rubble and aggregates B: Highway & pavement maintenance (kerb / paving stone cutting) C: Repointing - Removal of brickwork mortar using power tools. D: Abrasive blasting - High pressure cleaning of surfaces (buildings) using (non-silica) abrasives., E: Tunnel construction - Drilling and shotcreting.

Control strategy: Silica Essentials Control approaches: W = Water suppression, LEV = Local exhaust ventilation, LEV = Local exhaust ventilation

APPENDIX C STANDARD INDUSTRIAL CLASSIFICATION SUBDIVISIONS

The breadth of the construction industry is illustrated by the groups contained in Division 45, Construction, in the UK Standard Industrial Classification, the key to one of the Office of National Statistics' (ONS) analyses of UK employment.

At the time of this SBS work the classifications in use were those in the "UK Standard Industrial Classification of Economic Activities 2003 – SIC (2003)" (Ref g), although it should be noted that the 2007 classification will supersede the 2003 version in January 2008.

The descriptions of the subdivisions are reproduced below

Division 45 CONSTRUCTION
This division includes:
- new construction, restoration and ordinary repair

Group 45.1 Site preparation

Class 45.11 Demolition and wrecking of buildings; earth moving (approx 8000)
This class includes:
- demolition or wrecking of buildings and other structures
- clearing of building sites
- earthmoving: excavation, landfill, levelling and grading of construction sites, trench digging, rock removal, blasting, etc.
- site preparation for mining: overburden removal and other development and preparation of mineral properties and sites

This class also includes:
- building site drainage
- drainage of agricultural or forestry land

Class 45.12 Test drilling and boring

This class includes:
- test drilling, test boring and core sampling for construction, geophysical, geological or any other similar purpose

Group 45.2 Building of complete constructions or parts thereof; civil engineering

Class 45.21 General construction of buildings & civil engineering works
45.21/1 Construction of commercial buildings
This subclass includes:
- assembly and erection of prefabricated commercial buildings on the site

45.21/2 Construction of domestic buildings
This subclass also includes:
- assembly and erection of prefabricated domestic buildings on the site

45.21/3 Construction of civil engineering constructions
This subclass includes:
- construction of civil engineering constructions:
-. bridges, including those for elevated highways, viaducts, tunnels and subways
-. long distance pipelines, communication and power lines
- urban pipelines, urban communication and power lines; ancillary urban work
- assembly and erection of prefabricated civil engineering constructions on the site

Class 45.22 Erection of roof covering and frames

This class includes:
- erection of roofs
- roof covering
- waterproofing

Class 45.23 Construction of highways, roads, airfields and sport facilities

This class includes:
- construction of highways, streets, roads, other vehicular and pedestrian ways
- construction of railways
- construction of airfield runways
- construction work other than of buildings for stadiums, swimming pools, gymnasiums, tennis courts, golf courses and other sports installations
- painting of markings on road surfaces and parking lots

Class 45.24 Construction of water projects (approx 1500)

This class includes:
- construction of:
. waterways, harbour and river works, pleasure ports (marinas), locks, etc.
. dams and dykes
- dredging
- sub-surface work

Class 45.25 Other construction work involving special trades

This class includes:
- construction activities specialising in one aspect common to different kinds of structures, requiring specialised skills or equipment:
. construction of foundations, including pile driving
. water well drilling and construction, shaft sinking
-erection of not self-manufactured steel elements
-steel bending
. brick laying and stone setting
-scaffolds and work platform erecting and dismantling, including renting of scaffolds and work platforms
. erection of chimneys and industrial ovens

Group 45.3 Building installation and completion

Class 45.31 Installation of electrical wiring and fittings

This class includes:
- installation in buildings or other construction projects of:
. electrical wiring and fittings
. telecommunication systems
. electrical heating systems
. lifts and escalators
. fire alarms
. burglar alarm systems
. residential antennas and aerials
. lightning conductors, etc.

Class 45.32 Insulation work activities

This class includes:
- installation in buildings or other construction projects of thermal, sound or vibration insulation

Class 45.33 Plumbing

This class includes:
- installation in buildings or other construction projects of:
. plumbing and sanitary equipment
. gas fittings
. heating, ventilation, refrigeration or air conditioning equipment and ducts
. sprinkler systems

Class 45.34 Other building installation

This class includes:
- installation of illumination and signalling systems for roads, railways, airports and harbours
- installation in buildings or other construction projects of fittings and fixtures not elsewhere classified

Group 45.4 Building completion

Class 45.41 Plastering

This class includes:
- application in buildings or other construction projects of interior and exterior plaster or stucco including related lathing materials

Class 45.42 Joinery installation

This class includes:
- installation of not self-manufactured doors, windows, door and window frames, fitted kitchens, staircases, shop fittings and the like, of wood or other materials
- interior completion such as ceilings, wooden wall coverings, movable partitions, etc.

Class 45.43 Floor and wall covering
- laying, tiling, hanging or fitting in buildings or other construction projects of:
. ceramic, concrete or cut stone wall or floor tiles
. parquet and other wood floor coverings
. carpets and linoleum floor coverings including of rubber or plastic
. terrazzo, marble, granite or slate floor or wall coverings
. wallpaper

Class 45.44 Painting and glazing

This class includes:
- interior and exterior painting of buildings
- painting of civil engineering structures
- installation of glass, mirrors, etc.

Class 45.45 Other building completion

This class includes:
- installation of private swimming pools
- steam cleaning, sandblasting and similar activities for building exteriors
- other building completion and finishing work not elsewhere classified

Group 45.5 Renting of construction or demolition equipment with operator

Class 45.50 Renting of construction or demolition equipment with operator

APPENDIX D: CONTROL AND RPE COMPETENCY SURVEY TABLES

Control competency descriptors

Control Rating	Description
0	Evidence of unacceptable levels of over-exposure brought about through manifest failures to recognise hazard and risk coupled with a failure to provide any form of controls. (As a guide exposures at least twice relevant occupational exposure limit)
1	Evidence of unacceptable levels of over-exposure brought about through failures to recognise hazard and risk and take appropriate steps to control. Typically: • Absent or inadequate COSHH assessment • Evidence of rudimentary or inappropriate engineering controls • Controls appropriate only for lower level of risk • No supporting evidence of adequate control • No records of examination and test of lev • Poor maintenance of plant, enclosures and controls • Poor training of operators • No awareness of hazard, levels of exposure or risk • Poor management
2	Evidence of over-exposure. Some understanding of hazard and risk and some controls in place but not receptive to need to improve. Typically: • Inadequate COSHH assessment • Engineering controls poorly maintained and/or poorly positioned • Uncertain of adequacy of control • Limited understanding of exposures • Limited training of operators • Some use of RPE • Poorly informed management and supervision
3	Occasional over-exposure. Reasonable awareness of hazard and risk and desire to improve. Typically: • Reasonable COSHH assessment recognising main concerns • Application of reasonably effective controls at process • Reasonable levels of maintenance • Some understanding of exposures but few over-exposures • Limited training of operators • Some use of RPE • Reasonably informed management • Some supervision
4 The COSHH Essentials Standard	Adoption of good control practice consistent with risk. Reasonable awareness of hazard and risk and knowledge to implement effective strategies. Typically: • Comprehensive COSHH assessment • Aware of literature and information sources • Application of appropriate, effective, well maintained controls at process • Management and operator understanding of exposures • Well trained operators • Designated areas and use of RPE when appropriate • Well informed management • Competent supervision Evidence of coordinated approach to control – skills and knowledge available
5	Exemplary control consistent with risk. Typically: • Comprehensive COSHH assessment

Control Rating	Description
	• Literature and guidance to hand • Competent well-trained staff at all levels • Documented procedures • Exposure and risk understood at process • No evidence of over-exposure • Evidence of engagement of all stakeholders • All aspects of process considered

RPE competency descriptors

Rating	Description
NR	RPE not required to achieve adequate control
1	RPE required to achieve adequate control. No evidence of use or provision of suitable and adequate RPE
2	RPE used to achieve adequate control. Evidence of provision of suitable and adequate equipment but strong evidence of poor practices in use: • Limited evidence of selection process and face fit testing. • Equipment normally available but anticipated problems with use • Poor storage • No evidence of adequate training programme • No assessment of level of residual risk
3	RPE used to achieve adequate control. Evidence of provision of suitable and adequate equipment and some evidence of good practices. Limited evidence of management controls in use: • Face fit testing • Equipment readily available and used • Appropriate storage facilities • Adequate initial training • Operator can answer questions about use of RPE • Some understanding of role of rpe in reducing residual risk
4	RPE used to achieve adequate control. Verifiable policy on RPE linked to COSHH assessment. Strong evidence of selection of suitable and adequate equipment and good practices in use. Appropriate zoning of workplace and adequate supervision and control. Some minor concerns over procedural aspects and management control of programme: • Verifiable policy on RPE linked to COSHH assessment. • Face fit testing programme • Equipment routinely available and range of products available through selection process • Appropriate storage facilities • Initial training and refresher training • Operator understands role of RPE in controlling exposure • Clearly defined roles and responsibilities
5	RPE used to achieve adequate control. Evidence of exemplary RPE programme with only minor deviations from agreed practices and policies. • Verifiable policy on RPE linked to COSHH assessment. • Face fit testing programme • Wide range of appropriate equipment available for all users • Appropriate storage facilities and procedures to allow audit • Initial training and routine refresher training • Operators understand role of RPE in controlling risk • Everyone understands roles and responsibilities

7 REFERENCES

Chisholm, J 1999: Respirable Dust and Respirable Silica Concentrations from Construction Activities. Indoor Built Environment 1999; 8:94-106

Flynn & Susi, 2003: Engineering controls for selected silica and dust exposures in the construction industry – a review. Appl. Occup. Environ. Hyg. 18: 268 - 77

HSE 2002: The Control of Substances Hazardous to Health Regulations 2002, SI 2002/2677 The Stationery Office 2002 ISBN 0 11 042919 2

HSE 2003 Regulatory Impact Assessment (RIA) on proposals to reduce the UK Occupational Exposure Limit for Respirable Crystalline Silica, available as http://www.hse.gov.uk/ria/chemical/reduceoccexp.pdf

HSE 2004: The Control of Substances Hazardous to Health (Amendment) Regulations 2004, SI 2004/3386 The Stationery Office 2004 ISBN 0 11 051407 6

HSE 2005: EH40/2005 Workplace exposure limits, ISBN 0-7176-2977-5, as amended 2007 (http://www.hse.gov.uk/COSHH/table1.pdf)

HSE 2007: Table 1:List of approved workplace exposure limits http://www.hse.gov.uk/COSHH/table1.pdf

HSG 173 'Monitoring strategies for toxic substances' ISBN 0 7176 1411 5

Lumens and Spee (2001.) Determinants of Exposure to Respirable Quartz Dust in the Construction Industry. Ann. Occup. Hyg., vol 45, no7, 585-595, 2001.

MDHS 14/3; General methods for sampling and gravimetric analysis of respirable and inhalable dust. Available at http://www.hse.gov.uk/pubns/mdhs/pdfs/mdhs14-3.pdf

MDHS 51/2: Quartz in respirable airborne dust, HSE 1988 ISBN 0 7176 02559

MDHS 101 - Crystalline silica in respirable airborne dusts. HSE 2005 ISBN 0-7176-2897-3

Northage & Heathfield 1995 Technical Development Survey (TDS) – Silica In Construction - internal HSE report

ONS (2003): UK Standard Industrial Classification of Economic Activities 2003 – SIC (2003)"

ONS 2005: UK Business: Activity, Size and Location – 2005, UK Office for National Statistics.

Rappaport et al. 2003: Rappaport, S.M; Goldberg,M; Susi,P and Herrick, R. Excessive Exposure to Silica in the US Construction Industry. Ann. Occup. Hyg., vol 47, no2, pp111-122, 2003.

Yassin et al, 2005: Yassin, A; Yebesi, F and Tingle, R. Occupational Exposure to Crystalline Silica Dust in the United States, 1988 – 2003. Environmental health Perspectives Vol 113 No3 March 2005

Published by the Health and Safety Executive 02/09

Health and Safety
Executive

Silica baseline survey

Annex 2 Construction sector

Aims and Objectives

This Silica Baseline Survey aims to develop baseline intelligence on exposure and control of respirable crystalline silica in key industry sectors. These sectors are:

- Brickworks and Tile Manufacture
- Stonemasonry
- Quarrying
- Construction

The objectives are:

1) to establish whether exposure control practices (both the application of engineering controls and the use of RPE) are adequate to reduce exposures below the WEL for RCS
2) to form an opinion about the long-term reliability of the controls
3) to identify common causes of failures of exposure control
4) to provide data by which the effect of HSE interventions can be assessed.

This annexe to the main SBS report includes the site visit data and detailed discussion of observations in the construction sector.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

RR689

www.hse.gov.uk