

A Regulatory Impact Assessment (RIA) on proposals to reduce the UK Occupational Exposure Limit for Respirable Crystalline Silica (RCS)

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1. PURPOSE AND INTENDED EFFECT OF MEASURE

(i) Issue and Objective

1. A recent HSE review of the ill-health effects resulting from workplace exposure to respirable crystalline silica (RCS) revealed unacceptable risks at the existing occupational exposure limit.

2. The objective of this RIA is to assess the regulatory impact of the proposals to reduce the incidence of newly diagnosed cases of occupational ill health resulting from exposure to respirable crystalline silica. This is a target that will contribute to HSE's ongoing Chemicals Programme, which in turn supports HSC's strategy for workplace health and safety in Great Britain to 2010 and beyond.

3. Crystalline silica (mainly occurring in the form of quartz) is one of the most abundant minerals in the earth's crust. It is present in almost all types of rock, sands, clays, shales and gravel. It is also a major constituent of construction materials such as bricks, tiles and concrete. Hence, crystalline silica is of great economic importance. However, respirable crystalline silica is one of the most aggressive, lung damaging dusts that can be encountered in the workplace. Historically, respirable crystalline silica dust has been responsible for a huge burden of occupational ill health, with countless deaths from silicosis and silicotuberculosis. Heavy and prolonged exposure to respirable crystalline silica is also a cause of lung cancer. Improvements in workplace standards of control have led to a marked improvement in ill-health statistics in the UK since the 1930-1950s. However, although silicosis is no longer a major industrial disease in this country, it is not completely eliminated. There were 150 people that received compensation for silicosis in 2002, and the annual incidence of silicosis has shown no sign of a decline over the last 13 years.

4. A recent evaluation of the scientific evidence on respirable crystalline silica by HSE (HSE Phase 1 review 2002) indicates that there is a 20% risk of developing silicosis at the level of the current workplace exposure limit (WEL) for respirable crystalline silica. The value of the WEL is 0.3 milligrams of respirable crystalline silica per cubic metre of air averaged over an 8-hour time period (expressed as 0.3 mg.m^{-3}). In Europe the Scientific Committee on Occupational Exposure Limits (SCOEL), which comprises experts in occupational health drawn from all Member States, issued a recommendation to the European Commission in 2002 stating that to control against silicosis, any Occupational Exposure Limit (OEL) would need to be below 0.05 mg.m^{-3} . These developments strongly undermine the current WEL and therefore HSE considers it to be a priority to develop a more stringent regulatory position on respirable crystalline silica.

5. The policy options open to HSE were considered as part of an initial RIA. Of these options only a revision to the OEL for respirable crystalline silica (RCS) was deemed feasible. All the options considered in the initial RIA are set out in section 2 of this document. This RIA will therefore estimate the cost and benefits to British industry of complying with a new OEL for RCS. This RIA does not consider the costs and benefits of the options that were deemed not feasible. Given the timing of this initiative, the new OEL would be implemented under the intended new OEL framework as a workplace exposure limit (WEL). The requirements for complying

with the WELs are given on page 9/10. In order to provide a comprehensive basis for developing a new WEL, the RIA focuses on the costs and benefits of four potential limit values ranging from 0.3 mg.m⁻³ (the current UK Maximum Exposure Limit), 0.1 mg.m⁻³, 0.05 mg.m⁻³ to 0.01 mg.m⁻³. Costs and benefits accruing from the possible change in limit will be estimated for all sectors of British industry affected by these proposals.

6. Before changes in regulations can be recommended to the Health and Safety Commission (HSC), HSE has to make sure that it has all the relevant information on the associated costs and benefits. The information contained in the RIA will help HSC to decide whether to consult on a proposal for a revised limit for RCS. A summary of the RIA will then be published as part of a formal HSC Consultation Document. Stakeholders will therefore have the opportunity to comment on the completed RIA and on the proposal that results. The completed RIA will also be available as information source during potential future discussions in Europe on a possible Binding Limit. In the shorter term, it will clarify whether a value of 0.1 mg.m⁻³ (8-hour TWA) is reasonably practicable for the UK at present.

(ii) Background

7. Crystalline silica is found almost everywhere in the earth's crust, of which it comprises around 12% by weight. It is present as either a major component or a minor contaminant in varying amounts in sands, muds, shales and in rocks. Dust given off from working with these materials, if fine enough to be breathed deep into the lungs, is termed "respirable". Ambient respirable crystalline silica levels in US cities are around 0.003 mg.m⁻³ (Moore, 1999).

8. Crystalline silica is present in naturally occurring minerals and manufactured products in the following percentages:

Naturally occurring minerals

Ball clay – 15 to 30%
Basalt – up to 5%
Calcined diatomite – 25 to 65%
China stone – up to 50%
Dolerite – up to 15%
Flint – more than 90%
Granite – up to 30%
Industrial grade talc – up to 30% but some are quartz-free.
Ironstone – up to 15%
Kaolin (china clay) – less than 5%
Limestone, chalk, marble 1 to 2%
Sand, gravel, flint – more than 70%
Sandstone, gritstone, quartzite – more than 70%
Shale – 40 to 60%
Slate – up to 40%

Products containing crystalline silica

Brick – up to 30%

Concrete, cement, mortar 25 to 70%

Plastic composites – up to 80%

Silica flour (either quartz or cristobalite flour) – 100%

Tile – 30 to 45%

9. Although quartz is the main form of crystalline silica, there are other crystalline forms (known as polymorphs). Of the other polymorphs, only cristobalite is of any real industrial relevance. Quartz can convert into cristobalite when it is heated to very high temperatures (1600°C). This can happen in the bricks used to line industrial furnaces and kilns. Therefore, workers can be exposed to cristobalite in maintenance and furnace-wrecking activities. In the silica flour industry, cristobalite flour is produced for certain applications e.g. for the white paint used in road markings. Calcined diatomaceous earth is used as a filtration medium in some workplaces, and this is rich in cristobalite. So, although the vast majority of occupational exposures to crystalline silica are to quartz, there is some occupational exposure to cristobalite. There has been a widely held belief that cristobalite is more toxic than quartz, but a review of the toxicological evidence by HSE (reference to the Phase 1 review) did not support this belief. The review concluded that there can be variability in the toxic potency of different samples of quartz and cristobalite, and that no overall generalisations about their relative toxicity can be made. Some samples of quartz may be more toxic than cristobalite and vice-versa.

Measurement of silica

10. The sampling and analytical methods for quartz and cristobalite, the most common polymorphs of crystalline silica, are well established (MDHSs 14/3, 37, 51/2 and 76; a new MDHS for respirable crystalline silica – MDHS 101- is almost ready for publication. This MDHS will replace MDHSs 37, 51/2 and 76). For a 4-hour air sample, the methods give satisfactory precision at 0.3 mg.m⁻³. At 0.1 mg.m⁻³, the precision is poorer but still adequate for compliance monitoring and enforcement. At 0.05 mg.m⁻³, the analytical results for most samples will be valid as evidence but may fall short of the standard required for legal proof because of the deterioration in precision. Measurement at 0.01 mg.m⁻³ is just practicable for laboratory test filters but not for field samples.

11. WELs of 0.05 or 0.01 mg.m⁻³ would not be enforceable in all instances given the limitations of present sampling and analytical methods. Analytical methods for the measurement of airborne RCS need to provide measures of exposure with sufficient precision to support enforcement activity, should this be deemed necessary. Ideally, analytical methods need to be able to cope with both 4-hour and 8-hour TWA periods, given that some workplace tasks may only be a few hours in duration. For RCS, if the WEL were set at 0.1 mg.m⁻³, then the available analytical methods are perfectly adequate to support enforcement. If the WEL were set at 0.05 mg.m⁻³, there would be no enforcement problems if workplace exposures were markedly in excess of the WEL (>0.1 mg.m⁻³). In such circumstances there would be no difficulty in showing an exceedence of the WEL. However, if exposures to RCS were hovering around 0.05 mg.m⁻³ and only a 4-hour sample was taken, then the amount of RCS collected on the filter would be so low that it would not allow precise

measurement. Hence, there might be a difficulty in respect of enforcement in this particular circumstance.

12. Preliminary trials at the Health and Safety Laboratories in Sheffield suggest that better detection and precision at low airborne concentrations are achievable by sample treatment. This combined with improvements in sampling (high-flow-rate samplers) and in XRD equipment give scope for extending practical sampling and analysis down to 0.05 - 0.02 mg.m⁻³ but this will require development and validation. Measurement at the 0.01 mg.m⁻³ level would probably require transmission electron microscopy (TEM) which is a much more expensive technique.

Regulatory position

13. On the introduction of the COSHH Regulations in 1989 an OES of 0.1 mg.m⁻³ (8 hour TWA) was established for quartz and an OES of 0.05 mg.m⁻³ was established for cristobalite, on the basis that cristobalite might be more harmful (a suspicion not borne out by further work). However, the OES was withdrawn and a MEL for RCS (applying to both quartz and cristobalite) of 0.4 mg.m⁻³ (8-hour TWA) was introduced in 1992, following consideration of all the relevant information at that time by the Health and Safety Commission's Working Group on the Assessment of Toxic Chemicals (WATCH) and the Advisory Committee on Toxic Substances (ACTS). In 1997, the value of the MEL was adjusted to 0.3 mg.m⁻³ following adoption of the ISO/CEN sampling convention for respirable dusts.

14. In making its original decision, ACTS was influenced by representations from the quarry industry, that they could not reasonably comply with the former OES of 0.1 mg.m⁻³. However, in doing so ACTS was concerned that there should be no relaxation in existing standards of control, particularly in those industrial sectors where exposure levels were lower and the sectors were already complying with the original OES of 0.1 mg.m⁻³. Industries that had already demonstrated their ability to control to 0.1 mg.m⁻³ or below were expected to continue to do so. Accompanying the MEL was a package of industry-specific guidance.

15. RCS has been reviewed by the EU Scientific Committee on Occupational Exposure Limits (SCOEL). SCOEL is a committee consisting of independent experts in occupational health from Member States. SCOEL provides the scientific basis for EU Occupational Exposure Limits.

16. SCOEL has recommended to the European Commission that to control against silicosis, any Occupational Exposure Limit for RCS would need to be below 0.05 mg.m⁻³ (8-hr TWA). At this stage this does not constitute a formal proposal for a limit. However, we anticipate that the next step will be for the European Commission to request information from Member States and social partners on a proposed limit for RCS, and given the SCOEL conclusion, we anticipate that discussions on a proposed Binding Limit value are likely to centre on 0.05 mg.m⁻³.

17. Once the information from Member States is received, the Commission will propose a Binding Limit subject to negotiations between EU Member States. The negotiations will cover the technical feasibility of achieving control to the proposed limit, and on the adequate sensitivity of analytical techniques to measure reliably

airborne concentrations at the proposed limit value. There is however currently no timetable or work plan for the development of such an EU limit.

18. The responses to this RIA will consequently help to inform the UK position on negotiations on development of a European Union (EU) limit for RCS.

19. Table A summarises the current limit system for RCS in selected countries.

Table A: Occupational exposure limits for respirable crystalline silica

Country	OEL for RCS (mg.m ⁻³)	Comments
Australia	0.2	As a National Exposure Standard. 0.1 for cristobalite and tridymite. However, Australia is proposing to reduce the exposure standard for quartz and cristobalite to 0.13 mg.m ⁻³
Denmark	0.1	0.05 for cristobalite and tridymite
France	0.1	
Germany	0.15	
Netherlands	0.075	
Spain	0.1	0.05 for cristobalite and tridymite
Switzerland	0.15	
USA	0.05	As a TLV (ACGIH), which is a voluntary standard
USA	10/(%SiO ₂ +2)	As a PEL, which is a mandatory federal standard. The equation converts to around 0.1 mg.m ⁻³ for 100% SiO ₂ materials like sandstone.
USA	0.05*	“as respirable free silica for all crystalline forms of silica” - NIOSH

*This is a recommended standard.

(iii) Risk assessment

20. A simple risk assessment for an industrial chemical would consist of bringing together hazard data and the exposure profile to distil out the risks inherent in the use of the chemical. We have information on the hazards of RCS but because silica is widely distributed across a large number of industry sectors and the exposure profiles differ considerably, a simplified model cannot be used.

Summary of occupational exposure

21. Workers are exposed to RCS in a diverse range of industries including quarries, mines, ferrous and non-ferrous foundries, construction sites, ceramic manufacture, the heavy clay industry and brick making and stonemasonry. Workers can also be exposed to RCS in the manufacture and use of silica flour, made by finely milling

sand, and this flour is used as a hard-wearing filler in a very wide range of materials such as surface coatings, grouts, plastics, abrasives and soil improvers. HSE estimates that at least 100,000 workers are regularly exposed to RCS on a daily basis and many more workers can be exposed on an intermittent basis at values ranging up to several mg.m^{-3} for short periods.

Summary of health effects

23. Occupational exposure to RCS has the potential to cause silicosis. This is an irreversible, slowly progressing lung disease that can take years to develop. The main symptoms are breathing difficulties and a chronic cough. In severe cases, silicosis can be extremely disabling and can lead to premature mortality.

24. A recent HSE review of RCS, endorsed by HSC's Working Group for the Assessment of Toxic Substances (WATCH), a tripartite scientific committee, presented quantitative risk estimates for silicosis (published as EH75/4). The risk estimates are based on a study of hundreds of workers from a particular Scottish coalmine. This study provided exceptionally detailed and reliable information on the levels of exposure to RCS in these workers, and had long-term follow-up of the men to determine the eventual progression of silicosis 10 years after the mine had closed down. Major seams of sandstone were encountered in one part of the mine; the men cut through the sandstone for a period of about 10 years in order to get at the coal. In this part of the mine, the respirable dust in the air contained up to 60% quartz. Normally, coalmine dust contains up to around 10% RCS. Statistical analyses showed that the risks of silicosis could be largely explained by the exposures during the 1970s, and were not strongly related to the previous exposures to coalmine dust that occurred in the mine from the mid-1950s. Therefore, in order not to extrapolate beyond the region of relevant data, the risk estimates from this study refer only to a 15-year period of exposure, and not to the more traditional 40-year working lifetime occupational risk estimates.

Table B: Estimated quantitative risks of developing silicosis

15 years daily exposure to respirable crystalline silica dust at average airborne concentrations (for an 8-hour shift) of: (mg.m^{-3})	Risk of developing silicosis within 15 years following cessation of exposure
0.02	0.25%
0.04	0.5%
0.1	2.5%
0.3	20%

25. It is important to consider the relevance of these risk estimates to other occupational exposure scenarios involving exposure to RCS. In this study, workers were exposed to freshly cut surfaces of RCS generated by mechanical cutting into sandstone. Exposures to freshly cut surfaces of RCS occur in many common industrial tasks such as cutting, blasting, drilling, fettling, grinding, polishing, milling, or any other high energy abrasive process of materials containing crystalline silica. It does not matter whether the parent material is granite, sandstone, slate, or a

manufactured product such as brick or concrete. The concentration of RCS may vary but the nature of the freshly fractured RCS will be the same. Therefore, HSE considers that the risk estimates presented above are likely to have widespread relevance and applicability. HSE also notes that the risk estimates from this study seem very plausible and realistic when compared to other published occupational studies that provide quantitative risk estimates. There are four studies (in US and South African gold miners, Chinese tin miners and North American hard rock miners) that indicate higher risks of silicosis than found in the Scottish coal workers' study, but these studies did not have such detailed and accurate exposure data and so are considered less reliable. Six studies estimated lower risks but three of these did not include any long-term follow-up of silicosis development and so are likely to have underestimated the risks. One study (Vermont granite workers) could only inform on the risks from low level exposure to RCS and the findings were similar to the predicted risks from the study in Scottish coalminers for exposures less than 0.1 mg.m^{-3} (8-hr TWA). Therefore, the risk estimates from the study in Scottish coalminers are not extreme outliers when compared to the overall evidence-base, and HSE considers that they represent the most reliable estimates of silicosis risk available.

26. However, the HSE review also concludes that there is some variability in the toxic potency of RCS depending on whether or not the RCS is freshly fractured or "aged", and on the presence of adsorbed contaminants (aluminium-containing clay minerals). However, there is insufficient evidence to allow any quantification of differences in the risk of silicosis in different industrial settings.

27. Long-term exposure to RCS can lead to an increased risk of lung cancer. In 1997, the International Agency for Research on Cancer (IARC) published a monograph in which it was concluded that RCS was a cause of lung cancer in humans. In 1998, WATCH reached the conclusion that crystalline silica, inhaled in the form of quartz or cristobalite in occupational settings, is carcinogenic to humans. An HSE review of the lung cancer evidence published in 2002, and endorsed by WATCH, confirmed that there is sufficient evidence to indicate that RCS can cause lung cancer in humans. However, the HSE review also noted that the evidence for lung cancer is strongly suggestive, although not definitive, that there is an increased risk of lung cancer only in those with silicosis. It was concluded that control against the development of silicosis should minimise any increased risk of lung cancer.

28. Lung cancer due to RCS is a prescribed industrial disease in Great Britain and is subject to compensation through the Industrial Injuries Scheme. Statistics show that only a handful of cases receive compensation each year, with the highest number in 1999 when 7 men were diagnosed with lung cancer due to RCS. It is possible that the statistics underestimate the true number of lung cancer cases due to crystalline silica. This is because many workers or ex-workers with lung cancer would fail to suspect that past occupational exposures to RCS were the cause, and they would therefore be unlikely to come forward for compensation. Concerns about lung cancer emphasise the importance of controlling against the development of silicosis.

2. OPTIONS

29. As part of the transition to the recently introduced occupational exposure limit framework, all of the old MELs will become WELs, including that for RCS. In the

consultation document for the framework (*Proposal to introduce a new occupational exposure limits (OEL) framework*, [CD189](#)) the MELs for 15 of the substance that went forward as WELs will be flagged as needing review to determine the appropriateness of the limit value. The MEL for RCS is one such limit that came within this category (Table 2b of [CD189](#)). A review of RCS concluded that the current level of 0.3mgm^{-3} there is a 20% risk of contracting silicosis. Therefore no objections were raised regarding a review of the limit for Silica.

30. The WEL of 0.3mgm^{-3} comes into force in early 2005 when the previous maximum exposure limit (MEL) of the same numerical value will be directly transferred into the new OEL framework (as above). The current legal requirement is that employers must follow the principles of good-practice to control silica (as per Schedule 2A of COSHH) and the amount of silica in the workplace air must not exceed the WEL. (Under the previous system, the requirement was to reduce exposure so far as is reasonably practicable and in any case below the MEL.)

31. Several options were considered for this RIA.

Option 1: Do nothing. This option would mean leaving in place the current workplace exposure limit (WEL) of 0.3mg.m^{-3} .

This option is not acceptable for three reasons.

- Firstly, evaluation of the scientific evidence on RCS by HSE indicates that there is a 20% risk of developing silicosis at the level of the current WEL (0.3mg.m^{-3}). HSE considers that such a risk is not acceptable even if the legal requirement to control exposure is underpinned by a requirement to follow the principles of good-control practice.
- Secondly, the old MEL was set at the level of 0.3mg.m^{-3} because of difficulties of meeting anything lower within the quarry industry. Other industries could comply with a previous limit set at 0.1mg.m^{-3} and were expected to continue do so. This agreement has been largely overlooked since then. It is now recognised that technological advances mean that the quarries sector can control RCS to a standard equivalent to that in other sectors.
- Finally, in time a new UK limit may be needed to implement a European directive as a result of a review and consultation carried out by the EU Scientific Committee on Occupational Exposure Limits (SCOEL) - see page 6. Therefore the 'do nothing option' can equally be considered as an 'await action on a European level' option. As there is no timetable yet to even start work on a new EU limit for RCS, it is considered unacceptable to continue, for what is likely to be years, with our existing domestic level which, as explained, we now know is set at a level at which there is a 20% risk of developing silicosis.

Option 2: Get industry to impose a voluntary code (self-regulation) or produce joint HSE/industry guidance.

32. The option of producing a wider range of guidance will be time-consuming and likely to be superseded by the ongoing production of 'direct advice' control guidance sheets which will form part of HSE's electronic *COSHH Essentials* package

(<http://www.coshh-essentials.org.uk/>). This new HSE guidance will be a tool to aid the control of RCS in different industries covering specific processes and activities. It will address the fact that RCS is a process-generated dust. The control sheets will be developed in cooperation and agreement with industry (via tripartite advisory committees). Much guidance is already available but the new RCS direct advice sheets within COSHH Essentials will be produced in a standard format and be made freely available.

33. For RCS, control guidance is needed to supplement a legal exposure limit rather than instead of such a limit. The fact that RCS has a steep dose-response relationship, (a small increase in concentration of RCS significantly increases the risk of getting silicosis, at 0.1mgm^{-3} there is a 2.5% risk of silicosis, at 0.3mgm^{-3} this risk increases to 20%), means that it is not acceptable to rely on good practice guidance alone. The existing WEL of 0.3mg.m^{-3} is already reliant on published good-control advice (Schedule 2A of COSHH and in time specific guidance in *COSHH Essentials*). In conclusion, a voluntary code is not sufficient to ensure workers are protected from silicosis. Option 2 is therefore not a viable way forward in its own right. Additionally, as explained above under option 1, European directives might eventually supersede the option of a voluntary code.

Option 3: Introduce a revised workplace exposure limit (WEL). This is the preferred option and is justified by the first three reasons for not pursuing option 1.

34. This option is also justified to address the differences that exist between the requirements of existing WELs as opposed to what constituted adequate control for substances, such as RCS, that previously had a MEL. As explained under option 1, a WEL for a substance such as RCS (which is not a defined COSHH carcinogen) must simply not be exceeded. The duty for a MEL was, however, to reduce exposure so far as is reasonably practicable and in any case below the MEL. The transfer, in 2004, of the MEL for RCS into a WEL at the same numerical value therefore brings about the need to pursue option 3, e.g. the legal duty previously was to reduce exposure as far below 0.3mg.m^{-3} as reasonably practicable, now, with the existing WEL, it is to follow the principles of good practice and not to exceed 0.3mg.m^{-3} .

35. Option 3 follows logically on from the process started by the consultation document published by HSE in 2003 ([CD189](#)), which made the case for the recently introduced new occupational exposure limit framework. The first stage of this process was to transfer existing MELs to the new framework as WELs (which has now happened). The next stage was to review those 15 limits that ACTS concluded that, with improvements in control technology, it should be reasonably practicable to control to a lower level. The WEL for RCS is the first such limit to be reviewed. No objections were raised to this process as a result of CD189. The remainder of this regulatory impact assessment (RIA) therefore considers costs and benefits to industry of having a WEL for RCS at four potential levels, 0.01, 0.05, 0.1 and 0.3mg.m^{-3} . (The last of these values (0.3mg.m^{-3}), being the same as the existing limit, therefore equates to option 1, i.e. do nothing.) On the basis of these costs this RIA will conclude with the recommendation of one specific value for a new WEL for RCS.

3. INFORMATION SOURCES AND BACKGROUND ASSUMPTIONS

36. The appendices contain information on the organisations contacted by HSE during the preparation of this RIA.

37. The base year for the cost and benefit calculations is 2003. Costs and benefits have been discounted at 3.5% in line with Treasury recommendations. Earnings have been updated by 1.8% to account real increases, while health benefits have been updated by 2% to account for real increases in GDP per capita.

4. BENEFITS

Health benefits

38. This section examines the benefits from reducing three types of ill health outcomes associated with exposure to RCS. These are lung cancer, fatal silicosis, and radiological silicosis (ILO 2/1).

39. The WELs considered in this exercise are those listed below:

1. 0.3 mg.m^{-3} *Although this is the current limit, HSE believes that there are workers who are currently exposed above this limit.*
2. 0.1 mg.m^{-3}
3. 0.05 mg.m^{-3}
4. 0.01 mg.m^{-3}

40. Estimating the number of cases of ill health that will be prevented under each of these limits requires several elements. The first is an estimate of current exposures, and of the numbers of workers exposed at different levels. Secondly, we require an estimate of the exposure pattern after application of the regulations. Finally, for each health endpoint we want to include we must have an estimate of the relationship between exposure and disease occurrence.

41. Our estimate of the numbers of workers exposed at different levels is set out in table C. It was based on exposure data collected in the course of the RIA preparation and it is itemised in Annex 4 under the individual industry sectors.

Table C: Estimates of RCS exposure in British industry and the approximate numbers exposed.

Sector	Total numbers in the industry sector	Total numbers exposed above 0.01 mg/m^3	Total numbers exposed above 0.05 mg/m^3	Total numbers exposed above 0.1 mg/m^3	Total numbers exposed above 0.3 mg/m^3
Foundry	25,000	4,500 ¹	2,750 ¹	1,000 ¹	500 ¹

Ceramics	25,000	4,250 ¹	1,750 ¹	250 ¹	175 ¹
Brick and heavy clay	6,000	4,980 ¹	4,320 ¹	1,320 ¹	24 ¹
2. QUARRIES	35,000	2,800 ¹	1,400 ¹	1,050 ¹	210 ¹
3. SLATES	1,000	1,000 ¹	1,000 ¹	1,000 ¹	0 ¹
Industrial minerals – silica sand quarrying	Included under quarrying numbers				
Industrial minerals – silica flour production	40	32 ²	32 ²	32 ²	0
Use of silica - containing industrial minerals	2,500	50 – 1,000 ³	10 - 500 ³	0 – 100 ³	0 ³
Construction (See 4&5 below)	1,600,000	144,000 ⁴	144,000 ⁴	0 ⁴	0 ⁴
Construction	1,600,000	140,000 ⁵	12,500 ⁵	2,000 ⁵	0 ⁵
Stonemasonry	2,000	2,000 ³	1,000 ³	400 ³	100 ³
Total ⁶	1,696,500	159,612 – 164,562	28,762 – 156,752	5,052 – 7,152	1,009

1 = based on 2003 HSE questionnaire.

2 = based on industry data.

3 = based on current HSE estimate

4 = based on 2003 HSE questionnaire (but likely to be a severe underestimate of the total exposures)

5 = based on HSE assumptions of potential extra costs (section 46)

6 = heavily biased by large uncertainties in the construction industry

42. For the present calculation we have taken three endpoints: radiological silicosis; death from silicosis; and death from lung cancer. We have taken the dose response

coefficients for radiological silicosis from the recent HSE review of silica (ref). For our initial estimate of the level of deaths from silicosis we adopted the exposure-response coefficient estimated by the meta-analyses prepared for the IARC review of silica¹. However this predicted an annual number of silicosis deaths well in excess of the numbers currently recorded in the national mortality statistics and with the majority of deaths arising from the two lowest exposure categories.

43. We have therefore assumed that the exposure response relationship for fatal silicosis will reflect that for radiological silicosis (i.e. showing a non-linear relationship between exposure and outcome), and scaled this relationship so as to predict the currently observed annual number of fatal silicosis cases given exposures estimated in table C.

44. To predict the number of lung cancers (assumed all to be fatal), we noted that the number of excess lung cancers in the six cohorts in the IARC meta-analyses in which both silicosis and lung cancer data were published was, overall, very close to the number of fatal silicosis cases^{2,3}. We have therefore assumed that the same would apply in the UK exposed population.

45. All these sources give outcome rates in terms of cumulative incidence up to some stated age (or time point after exposure). For the calculation of health benefits, these risks need to be converted into an annual flow of cases occurring (or avoided). We convert the lifetime number of deaths produced by a given exposure to an annual flow by dividing the lifetime total by the duration of the exposure which produces those lifetime cases.

46. The full effect of changes to workplace exposures cannot appear before the last person who has experienced conditions before the change to exposures has reached the maximum age at which we count cases. In the present calculation we have assumed exposure starts at age 20, and counted cases incidence up to the age of 79 (inclusive). The full annual case saving is therefore achieved 60 years after the effective date of the regulatory change. It can be shown theoretically that the time profile of increasing benefits is proportional to the growth in the age specific incidence rates of the outcome in question. Both lung cancer and silicosis mortality rates increased with age at something between the square and the cube of age. We have therefore estimated the growth of annual cases saved to be proportional to (year after regulation change)^{2.5}, reaching the maximum saving in year 60.

¹ Exposure-response analysis and risk assessment for silica and silicosis mortality in a pooled analysis of six cohorts – A 't Mannetje, K Steenland, M Attfield, P Boffetta, H Chechoway, N Deklerk and R-S Koskela

² *Quantitative exposure-response for silica dust and lung cancer in Vermont granite workers* – M Attfield and J Costello

³ *Exposure-response analysis and risk assessment for lung cancer mortality in a pooled analysis of six cohorts* – K Steenland, A 't Mannetje, M Attfield, P Boffetta, H Chechoway, N Deklerk and R-S Koskela

47. Once the numbers of prevented cases have been estimated, it remains to express them in monetary terms. In general, three major types of economic health benefits can be valued in this way. These are:

- Pain, grief and suffering (human costs)
- Medical treatment
- Lost output and consumption

48. Other minor benefits, mostly associated with administration, are also relevant. However these are small and are not usually included in RIAs. To this extent, the benefits estimated below are understated.

Lung cancer

49. HSE predicts that over a sixty-year period the following number of RCS lung cancer fatalities will be prevented at the various proposed limits:

- 0.3 mg.m⁻³: 36 fatalities
- 0.1 mg.m⁻³: 185 fatalities
- 0.05 mg.m⁻³: 300 fatalities
- 0.01 mg.m⁻³: 455 fatalities

50. Cancer is usually assumed to instil particular dread among people. Although the form of this dread is not specified, fear of acute suffering, extremely unpleasant treatment and the low survival rate for some cancers are thought to play a part. To try to account for these fears, HSE has doubled the DfT roads VPF⁴.

51. The medical cost of treating cancer is highly variable depending on the form of chemotherapy chosen by the specialist and the number of hospital visits. HSE has assumed that the average cost of treatment lies between £5,000 and £10,000⁵. Because lung cancer is highly virulent, treatment is assumed to occur in the year of death.

52. HSE has no information either on the average age at diagnosis of RCS related lung cancer or the distribution of ages. Given this uncertainty and the possibility that most people are diagnosed beyond the age of retirement, HSE has not estimated lost output and consumption for cases of RCS related lung cancer.

⁴ This approach is mentioned in the Treasury's Green Book.

⁵ This is loosely based on 5 to 10 hospital admissions for chemotherapy and appropriate palliative care. A rough cost per admission plus treatment was derived from DoH reference costs for 2002/03.

53. Combining all the assumptions and evidence presented above leads to the following estimated sixty-year benefits from preventing cases of lung cancer for the four limits (table D).

Table D: Benefits Over Sixty Years from Preventing Cases of Lung Cancer at Different Limit Values

	0.3mg.m ⁻³	0.1mg.m ⁻³	0.05mg.m ⁻³	0.01mg.m ⁻³
	£million	£million	£million	£million
Prevented human costs	21.73 to 36.21	115.6 to 192.6	187.9 to 313.2	284.8 to 474.6
Prevented medical costs	0.08 to 0.16	0.4 to 0.9	0.7 to 1.4	1.1 to 2.1
Prevented lost output	0.00	0.00	0.00	0.00
Total prevented costs	21.81 to 36.37	116.0 to 193.5	188.6 to 314.6	285.8 to 476.8

Radiological Silicosis (or silicosis that does not lead to premature death)

54. HSE estimates that over a sixty-year period the following number of silicosis cases will be prevented at the various proposed exposure limit values.

- 0.3mg.m⁻³: 110 cases
- 0.1mg.m⁻³: 547 cases
- 0.05mg.m⁻³: 883 cases
- 0.01mg.m⁻³: 1326 cases

55. HSE has no specific value that it can place on the human costs endured by victims of severe non-fatal silicosis. In such cases in the past, HSE has sometimes resorted to a three step process: Firstly the Department for Transport value of preventing a fatal road accident (Roads VPF⁶) is converted into the value of a life year (VOLY)⁷. Secondly, an assumption is made about how badly a disease affects the quality of a person's life. This is usually expressed in percentage terms, with 0% representing unaffected health and 100% representing death⁸. Finally the first two elements are multiplied together to give a monetised human cost per year, which is then applied to each year of suffering. Although this hybrid approach is not

⁶ The Roads VPF is taken by HSE as a reasonable estimate of the value of preventing the majority of deaths in the occupational health and safety context. This follows recommendations produced by Beattie et al, HSE research report 273.

⁷ On average a victim of a road accident has 39 remaining years of life. The VPF is assumed to represent a present value, in which discounting of 1.5% is implicit.

⁸ This is the approach followed in determining QALYs – Quality adjusted life years.

supported by theory, it nevertheless yields values in circumstances where no direct evidence is available.

56. In the case of silicosis, HSE took the human costs element of the Roads VPF (£819,000 in 2002 values), converted it into a figure representing the human cost per life year (£27,500 in 2002 values). For an estimate of the degree to which silicosis affects quality of life, HSE referred to DWP's Industrial Injuries Scheme. The diagnosis of "silicosis" takes into account the size and profusion of abnormalities detected on chest x-rays⁹. These abnormalities in themselves are not accurate predictors of the degree of disability. Indeed some patients with substantial chest X-ray abnormalities may only be marginally affected by the condition. Consequently, a broad disability band of 1% to 60% was chosen to capture the true level of disability suffered by silicosis patients¹⁰. Combining the cost per year and quality of life elements gave an estimated range of £300 to £16,500 for each year of suffering. The average age at which silicosis is diagnosed is 67. ONS reports that in 2002 the expected age at death of people who reach 65 was 81. On this basis, HSE assumed that on average people suffer silicosis for 14 years.

57. The prevented costs of medical treatment are difficult to estimate. The Department of Health publishes reference costs for medical treatment. The 2002/3 cost of hospital outpatient treatment for a sufferer of pneumoconiosis/fibrosis was £338. HSE has assumed that the average non-fatal silicosis sufferer requires outpatient treatment once every five to ten years, but visits their GP two to four times a year. HSE has previously estimated from Department of Health data that the cost of a GP consultation and subsequent prescription is £34 (in 2002 prices).

58. Although the average age at diagnosis of silicosis is beyond the normal age of retirement, there will nevertheless be some sufferers who will be diagnosed while they are still working. IIS figures (published on the HSE website) suggest that one third of non-coal dust and non-asbestos related pneumoconiosis cases are diagnosed in the 45 to 64 age group. Assuming that the average age at diagnosis within this sub-group is 60¹¹, HSE further assumes that the average loss of output per worker lies between two and five years¹². The loss of one year of output is valued at £27,000¹³.

⁹ The medical definition is 2/1 and above.

¹⁰ The assumption is made that the degree of disability and loss of quality of life are synonymous.

¹¹ This is justified on the basis that the distribution within the age category is likely to be skewed towards the upper limit.

¹² Workers in the relevant industries may on average retire at a lower age than 65. Furthermore, workers at risk from silicosis may operate in workplace that is generally more risky than average and consequently the chances of reaching retirement age without suffering some other form of injury or illness are lower than average.

¹³ Data from the 2002 New Earnings survey: SOC 89 "Plant and machine operatives", multiplied by 1.3 to account for non-wage labour costs.

59. Combining all the assumptions and evidence presented above leads to the following estimated sixty-year benefits from preventing cases of non-fatal silicosis for the four limits (table E).

Table E: Benefits Over Sixty Years from Preventing Cases of Non-Fatal Silicosis at Different Limit Values

	0.3mg.m ⁻³	0.1mg.m ⁻³	0.05mg.m ⁻³	0.01mg.m ⁻³
	£million	£million	£million	£million
Prevented human costs	0.30 to 17.92	1.5 to 90.3	2.4 to 145.7	3.6 to 218.7
Prevented medical costs	0.10 to 0.20	0.5 to 1.0	0.8 to 1.7	1.2 to 2.5
Prevented lost output	0.90 to 2.21	4.5 to 11.1	7.3 to 17.9	11.0 to 26.9
Total prevented costs	1.30 to 20.33	6.5 to 102.4	10.6 to 165.3	15.9 to 248.0

Fatal silicosis (silicosis that leads to premature death)

60. Over a sixty-year period, HSE predicts that the following number of silicosis fatalities will be prevented at the various proposed limits:

- 0.3mg.m⁻³: 36 fatalities
- 0.1mg.m⁻³: 185 fatalities
- 0.05mg.m⁻³: 300 fatalities
- 0.01mg.m⁻³: 455 fatalities

61. HSE has applied the human costs element of the DfT Roads VPF to each silicosis fatality¹⁴. Human costs of a fatal road accident are usually associated with nearly instantaneous death. However, silicosis fatalities are likely to involve a prolonged period of suffering before death. To account for this, HSE has adopted the methodology that it applied to non-fatal silicosis deaths but has used a different set of assumptions. After consulting a DWP Industrial Injuries Scheme expert, HSE has adopted a range of 50% to 100% disability to represent the loss of quality of life before death. Combining the VOLY (human costs) and quality of life elements gives an estimated range of £13,700 to £27,500 for each year of suffering. HSE has assumed that the average length of suffering prior to death ranges between 5 and 10 years.

62. Due to their acuteness, fatal cases of silicosis are likely to be more expensive to treat medically per year than the cost of treating non-fatal cases. The DoH 2002/03 reference costs for treating an inpatient with pneumoconiosis/fibrosis was £1521.

¹⁴ Although most silicosis deaths affect people who are significantly older than the typical road traffic accident victim, HSE has not use age-adjusted human costs. This approach is likely to be endorsed by forthcoming Treasury guidance on valuing risks.

HSE has assumed that such treatment is required between one and two times in the five year period of suffering, while outpatient treatment is given once every year or two years (at a cost of £338 per “finished consultant exercise”), and GP consultations are required four to eight times a year (at a cost of £34 per visit, including prescription costs).

63. HSE has assumed that cases of fatal silicosis generate the same amount of lost output as do other silicosis cases (see the assumptions above).

64. People who die of silicosis will of course be denied the consumption that they would have enjoyed if they had lived a full life. HSE has insufficient information to estimate this cost to individuals and therefore the aggregate costs below are understated.

65. Combining all the assumptions and evidence presented above leads to the following estimated sixty-year benefits from preventing cases of fatal silicosis for the four limits (table F).

Table F: Benefits Over Sixty Years from Preventing Cases of Fatal Silicosis at Different Limit Values

	0.3mg.m ⁻³	0.1mg.m ⁻³	0.05mg.m ⁻³	0.01mg.m ⁻³
	£million	£million	£million	£million
Prevented human costs	15.85 to 20.76	84.4 to 110.6	137.1 to 179.3	207.8 to 271.9
Prevented medical costs	0.06 to 0.25	0.3 to 1.4	0.5 to 2.2	0.7 to 3.3
Prevented lost output	0.36 to 1.12	1.9 to 6.0	3.1 to 9.7	4.7 to 14.7
Total prevented costs	16.27 to 22.13	86.6 to 118.0	140.7 to 191.2	213.2 to 290.0

Summary table (table G):

Table G: Benefits Over Sixty Years from Preventing All Diseases at Different Limit Values

	0.3mg/m ³	0.1mg/m ³	0.05mg/m ³	0.01mg/m ³
	£million	£million	£million	£million
Total prevented costs	39.38 to 78.83	209.2 to 413.9	339.9 to 671.1	514.9 to 1014.8

5 COSTS

Business sectors affected

66. Any workplace where RCS exposure occurs has the potential for increased costs to comply with a lower limit but coalmines are excluded because they are subject to different regulations.

67. For the rest of British industry, any division into sectors and subgroups for silica exposure is complicated by the ensuing overlap between any such systems. The main sectors have been arranged into the ones most clearly understood by UK industry and it is based predominantly on the divisions on the work-activity sections from the developing document - Silica Essentials - as at September 2003. See Annex two for the list of tables and control approaches. These industries are listed below:

- Foundry Industry (see para 70)
- Ceramics Industry (see para 74)
- Brick manufacture and Heavy Clay (see para 79)
- Quarry industry (see para 84)
- Industrial minerals and the production and use of Silica sand and flour (see para 90)
- Construction industry (see para 95)
- Stonemasonry industry (see para 98)

68. There is considerable overlap; many brick manufacturers have a quarry nearby to supply the raw material; stonemasons work in the construction industry as well in isolated workshops. Slate production is associated with quarrying. The production and use of silica flour emphasises this difficulty as this material is produced and used for a multitude of purposes in several different sectors.

Familiarisation Costs

69. HSE estimates that approximately 4,400 sites in Great Britain will be affected by the new regulations. Assuming that a manager on each site requires one to two hours to become familiar with the proposed regulation, and that the full economic cost of management time is approximately £28¹⁵, the total cost of familiarisation for all industries is estimated to be between £124,000 and £248,000.

(1) Foundry industry

70. HSE's Respirable Crystalline Silica Exposure Assessment Document (EH74/2, 1999) gave a figure of 25,000 employees in the foundry industry being exposed to silica, and we believe that there are around 300 sand foundries plus some die-casting foundries that also use sand, making a total of about 500 sites altogether.

71. The foundry industry produces shaped metal by pouring molten metal into moulds and allowing it to cool. There are two major sources of exposure:

¹⁵ HSE has taken SOC 124 "Personnel, Training and Industrial Relations Managers" as being typical of the kind of manager involved in familiarisation. The average hourly wage is taken from the New Earnings Survey 2002. 30% non-wage labour costs have been included.

72. Refractory material is used to line the furnaces, and high silica-content bricks are used in the structure. A major source of exposure occurs during removal or repair of these refractory linings or repair and removal of the bricks although brick-lined furnaces have become much less common in the last twenty years. The majority of foundries use sand as the main moulding medium. Silica sand for foundry use is both naturally processed and resin-coated. During knockout, shot blasting and fettling, exposure potential is high but as foundry sand usually contains silica, general maintenance and cleaning activities also have a risk. If recycled sand is used, there may be a build up of finer particulate, and exposure during sand reclamation and mixing may also occur. Usually the fines content of recycled sand is controlled by extraction and this is needed to maintain the integrity of the moulds.

73. Vigorous attrition of sand creates fine particles; major operations that can produce this attrition are shot blasting, reclaim, knock-off using hammers and fettling. Movement of sand on conveyors allows spillage, attrition and entrapment in warm air currents; blasting of sand into silos with consequent pipework wear also provides conditions suitable for RCS exposure.

(2) Ceramics industry

74. Ceramic is usually defined as “pertaining to industry or products containing clay or other silicates” but in this document, this sector is restricted to the production of pottery in its various forms. Pottery can be divided into three distinct types depending on their physical properties; earthenware, stoneware and china/porcelain. Earthenware is porous, whether glazed or not and is probably the most common type of pottery. Stoneware is a vitreous earthenware, and the glaze is usually applied before firing. Stoneware has good thermal shock properties and can be used in cooking.

75. China/porcelain is a general description that covers a range of more specialist pottery that is white, translucent and fully vitrified, and there are several sub-groups. Hard-paste china is a traditional form usually from Europe and the Far East, produced by a low-temperature biscuit firing which forms a porous material, with glaze being added and fired at a much higher temperature to form fully vitrified ware. Soft-paste china is produced by most UK companies and is formed from high temperature biscuit firing and the fully vitrified result is glazed and fired at a lower temperature. Bone china is special, soft-paste china containing animal bone ash.

76. In the ceramics industry, workplace cleanliness is the main pillar of control, with RPE being used for maintenance and cleaning. The use of “Type H” vacuum cleaners helps to keep floors clean, and an important control remains the wearing of work clothing specifically designed for use in potteries that prevents dust contaminating clothing and being released as a cloud into the wearer’s breathing zone.

77. Kiln-wrecking is always a very dusty job and is usually a job for contractors and not for foundry staff, but specialist staff may be exposed to RCS on a regular basis and the wearing of suitable RPE is essential, Kiln-repair is an ongoing process that also requires suitable RPE.

78. EH74/2 (1999) gave a figure of 25,000 employees in the ceramics industry being exposed to silica, and we believe that there are about 70 pottery companies in the UK. There will also be a number of small “craft” potteries around the country where RCS exposure is sporadic. However economic changes in the industry are resulting in an increase in the number of small craft potteries following the break-up of larger companies.

(3) Brick manufacture and heavy clay

79. The brick-making and the heavy clay industry covers a wide variety of clay brick and tile manufacturing, ranging from highly automated production of facing bricks with computerised kilns and processes to the traditional, labour-intensive hand-making processes.

80. Bricks are made from soft sedimentary rocks – clays, marls, shales and mudstones - that are prepared by being crushed, ground and mixed with water before being moulded, extruded, faced and shaped. Firing at temperatures between 900 and 1250⁰C causes partial vitrification or melting and converts the bricks to a durable form by forming a glass which helps to bind the materials, while inert components like quartz help prevent excessive shrinkage. There are three main methods of making bricks - soft mud moulding by hand or by machine, extrusion/wire-cutting, and semi-dry pressing (the Fletton process). Overall, there remain about 6000 employees involved in brick manufacture at about 70 sites in Great Britain.

81. The clay used for bricks contains up to 40% free silica. Highest exposures are found at clay preparation such as milling, transporting and screening, during facing of bricks (dressing with siliceous dust which produces localised exposures of RCS), and during de-hacking where silica dust from facings, frogs or from loose surface materials is made airborne. As in the ceramics industry, regular cleaning of floors and surfaces helps to reduce standing dust which can be crushed, made airborne and available for inhalation. Where coal and clinker residues are incorporated into the clays, these also contain RCS.

82. Clay tile manufacture is similar to brick manufacture. The total workforce in tile making is around 1000 spread over about 15 sites – predominantly small sites in the south of England. Concrete tiles make up about 60% of the market and clay tiles amount to only 10% of the market - amounting to about 100 million tiles annually. They are more durable and retain colour better and sell as a premium product.

83. There are also a few handcrafted tile producers but the processes involved are similar.

(4) Quarry industry

84. Quarries produce aggregates, surfacing, ready-mixed concrete, agricultural lime, industrial lime, mortar and slag. The sector is a complex industry where respirable crystalline exposure is dependent on many circumstances, with the major ones being the type of rock being worked and the job activity. Because of this multiplicity of factors, overall airborne dust exposure figures are difficult to use meaningfully and combined RCS exposure data can hide many of the relevant features.

85. The main activity in quarrying is the production of large quantities of low value minerals; the value of the product is important because this influences economic considerations when large capital costs are involved. EH74/2 (1999) gave a figure of 35,000 employees in the quarry industry being exposed to silica at between 2,500 and 3,000 quarries. However, the number of 'mineral operations' in the UK was stated to be about 1,400 in 1999 (Lavender, 1999) but their definitions may be different. The Quarry Products Association (QPA) currently estimate (2004) that there are up to 2,000 quarries and about 500 non-quarry sites which house ready-mix concrete, mortar or asphalt enterprises.

86. In this document, we will assume 2,000 sites.

87. The quarry sites may be categorised as follows:-

- (a) Sand/gravel quarries consisting of old glacial deposits where the material is already broken up. The stone is dug out and transported (by conveyor or dumper) for grading or processing. Products include building sand, concrete sand or gravel (used for concrete or drives)
- (b) Roadstone quarries consisting of hard stone where blasting is required to break up the cliff face before it is dug out. Bigger crushers are required.
- (c) Coating plants are located at quarries or railheads. Hardstone is heated and coated with bitumen.

At most sites, long conveyor belts with crossover points have the potential for spillage and for the blowing of this material downwind, and busy transport movements increase the potential for this RCS to become airborne.

88. Slate production, splitting and dressing are included as a separate section, and there are about 10 companies involved in slate production operating up to 50 quarries in the UK with possibly a thousand employees exposed to RCS. Of these quarries, about 12 have on-site workshops for slate production.

89. The production of silica sand, the conversion of some to silica flour, and the use of silica sand/flour is also reported in a separate section owing to the many specialist downstream applications for these products.

(5) Industrial minerals and the production and use of silica sand and flour

90. There are 25 silica sand sites in Great Britain.

91. Most silica sand is produced from unconsolidated sands and weakly cemented sandstones from areas which include Cheshire, Surrey, Bedfordshire, East Anglia and Scotland, by opencast quarrying. Silica sand can only be extracted where the mineral occurs and where extraction is economically feasible. This means that capital investment must be justified. There are thus few extraction sites, and replacing old or developing new process lines involves major investment decisions.

92. There are also about 20 working mines in which industrial minerals (such as potash, gypsum, limestone) are extracted. With one exception the silica content is

low, but all such mines retain the potential for RCS exposure during the excavation of surrounding rock.

93. Often the silica sand deposits are overlain with inferior grade sands that can be used only for construction purposes. Silica sand is used for glass production (about 45%), foundry casting (25%), ceramics, chemical production, filtration products, specialist building applications such as blocks, floor and roof tiles, flooring, rendering, roofing felt, cement and resin injection systems, equestrian surfaces, artificial turf, golf courses and sports pitches. About twelve UK companies produce about 4 million tonnes annually of silica sand at a number of sites. After quarrying, the sand is processed by washing and sizing and may be dried and bagged. Bagging of the sand and/or flour can be a dusty process and there remains a potential for RCS exposure during downstream handling of these bags. For use in the glass industry, the sand is further processed to remove chemical impurities, particularly iron and chromium.

94. Some of the silica sand produced at the quarry on site, is ground finely to produce silica flour by three companies, and this flour has a number of specialist uses. Sand may also be calcined at temperatures in excess of 1,000°C to produce cristobalite sand, which may be subsequently ground down to cristobalite flour. Currently, only one UK company produces cristobalite flour.

(6) Construction industry

95. EH74/2 (1999) recognised that in this industry, several hundred thousand workers could be exposed to respirable crystalline silica on an occasional basis but that HSE had little data on occupational exposure to RCS. This lack of information complicates both the costings and the benefits sections. The DTI website (www.dti.gov.uk/construction/stats/050304/pressrel050304.htm.) estimates that a total of 1,600,000 persons were employed in construction in October 2003 although HSE's internal figures suggest a slightly lower figure for the total employed. If we concentrate on employees likely to be exposed to RCS on a regular basis, we can include flooring contractors (11,700), plasterers (10,000), constructional engineers (9,800) demolition contractors (6,200), floor and wall tiling specialists (3,300), reinforced concrete specialists (2,000) and a miscellaneous group of around 97,000 – making a total of about 140,000 or around 10% of the total workforce.

96. A summary of the available exposure information was given in an HSE Information sheet (CIS 36) but it was further recognised that there were a wide range of activities within construction with the potential for RCS exposure.

97. The following sub-sectors were considered for costing on the basis of available information.

(a) Concrete-cutting saws

Many full time users cut concrete, ceilings and pipe runs on demand. Although numbers are difficult to estimate, we assume that there are about 150 companies with between 1 and 100 employees involved in this work with most firms being small. The full time cutters are responsible for between 50% and 75% of the total work. Kerb and paving stone cutting is a major source of

RCS exposure being done by casual workers who hire their equipment on a short-term basis.

(b) *Grit/sand blasting*

More than 350 abrasive blasting companies are listed but most are very small. Although sandblasting of articles is prohibited, sandblasting of buildings is allowed because they are not defined as articles.

(c) *Tunnelling*

The significant risks arise from tunnelling through high-silica rock, or when flints occur, and as a result of sprayed concrete application during the “New Austrian Tunnelling Method.” General work

This includes the many different tasks in the construction industry that can generate RCS exposure. Civil engineering drilling is included here and is similar to quarry drilling as the same drill pieces are used. “Scabbling” operations are a major source of RCS exposure.

(7) Stonemasonry industry

98. Stone-working takes place in workshops where fixed extraction ventilation is feasible, or on worksites where controls are limited to on-tool extraction for personal protection This section encompasses activities taking place in a workshop because stonemasonry work on building sites is considered under the construction sector. Workshop stone cutting produces products such as fireplaces, statues, and memorials. However, many kitchen companies now cut and abrade using a wide range of water-suppressed and dry abrading techniques to produce granite worktops and sinks.

99. EH74/2 (1999) suggests that 1,000 employees in the stonemasonry industry were exposed to silica out of a total of 2,000 stonemasons in the UK. However, the current HSE view is that this is an under-estimate and a figure of 2,000 stonemasons being exposed to RCS is more accurate.

6. COMPLIANCE COSTS TO BUSINESS

100. Table H below summarises the estimated total costs to GB industry to comply with potential new limits for RCS. This table was compiled using information below on compliance costs to each industry.

Table H: Summary of estimated GB costs to industry

Total Costs to industry for potential limits for RCS			
Potential new limit (mg.m ⁻³)	Initial capital costs (£ million)	Annual running costs (£ million)	60 year total discounted costs (£ million)
0.3	0.31	0.03	4.6 – 4.8
0.1	71.4	5.96 – 6.45	638 – 650

Total Costs to industry for potential limits for RCS			
Potential new limit (mg.m⁻³)	Initial capital costs (£ million)	Annual running costs (£ million)	60 year total discounted costs (£ million)
0.05	350.7	43.65 – 50.18	3,453 – 3,603
0.01	350.7	419.23 – 534.88	12,023 – 14,663

101. The sixty year discounted values can be expressed as an annualised cost¹⁶. At a strictly enforced limit of 0.3mg.m⁻³ the estimated annualised cost is between £180,000 to £190,000. At 0.1mg.m⁻³ the estimated annualised cost is £25,000,000. At 0.05mg.m⁻³ the estimated annualised cost lies between £134,000,000 and £140,000,000. The 0.01mg.m⁻³ estimated annualised cost is between £466,000,000 and £568,000,000.

Costs for typical businesses

102. There will be numerous types and sizes of businesses that would be affected by these proposals. In these circumstances it seems sensible to assess the costs for typical businesses in those sectors that are likely to be most heavily affected. This approach suggests that the quarries and construction sectors are most relevant. Using the assumptions of the relevant sections above, HSE estimates that the following costs apply at each of the proposed new limit values:

Table I: Typical costs to a quarries sector business

Limit value	Initial capital cost	Annual recurring cost
0.3mg.m ⁻³	Nil	Negligible
0.1mg.m ⁻³	£30,800	£1,650
0.05mg.m ⁻³	£162,400	£8,700
0.01mg.m ⁻³	£162,400	£32,900

¹⁶ This is the constant annual figure that when applied and discounted over a sixty-year period yields the sixty-year present value.

Table J: Typical costs to a construction sector business

Limit value	Initial capital cost	Annual recurring cost
0.3mg.m ⁻³	Nil	Nil
0.1mg.m ⁻³	£200	£2,000
0.05mg.m ⁻³	£500	£20,350
0.01mg.m ⁻³	£500	£291,350

103. Compliance costs to business in detail

104. Certain costs are common to all industry sectors and these are summarised below.

Respiratory Protection Programmes

105. HSE produced an estimate of the costs of various respiratory protection programmes (McAlinden, 1996) and these costs are based on 1994 figures. The totals include the costs of purchase, training, cleaning, inspection, storing, maintenance, record keeping and disposal. A summary is given below in table K, and some of these costs will be used for individual sector costs.

Table K: Calculated costs of RPE programmes (1994 figures)

Type of RPE	Annual cost - Capital	Annual time cost – training, cleaning, servicing
Single use disposable filtering face piece respirators	£288 - £840	Two hours.
Re-usable disposable filtering facemask respirators	£455 - £695	42 hours
Half-mask respirators	£295	54 hours
Full-face respirators	£441 - £851	94 hours
Power assisted respirators	£690 - £1181	100 hours
Powered hoods	£730	100 hours
Powered helmets	£306 - £1117	100 hours
Air-line equipment and self-contained breathing apparatus	Variable cost depending on the training and servicing arrangements	

106. These figures were accurate in 1994, but since then there has been added a requirement to face-fit RPE.

107. A large company sent in details (2003) of their face-fitting costs and they assumed a capital cost of £5,000 for the particle counting machine plus maintenance costs of £500 annually, and fitting costs of 2 hours annually per person. Their corresponding figures for the annual costs of the RPE were: BA (self-contained) £1,000 per set, BA (airline) £700 per set, half-face masks £100 - £200, disposable masks £20.

Monitoring for RCS

108. Although costs are dependent on quantity, an average cost for each RCS analysis is currently about £50, and the daily rate for a consultant on site to sample is around £500.

109. Although with present methods an analysis costs about £40-50 per filter at air RCS level of around 0.1 mg.m^{-3} , the analysis costs increase when sampling lower RCS air levels. Extra sample treatment may be required if air levels are below 0.1 mg.m^{-3} (see the section headed 'measurement of silica' - page 5) but improvements mentioned are unlikely to take the cost above £80-100. Transmission Electron Microscopy (TEM) analysis for asbestos costs at least £400 per filter, and more for difficult samples this may be the benchmark cost for RCS values around 0.01 mg.m^{-3} .

Training in the use of engineering controls

110. These costs will depend on the complexity of the equipment.

Personal protective equipment

111. This will cover the costs of suitable coveralls to prevent the build-up of dust on clothing. No extra costs have been calculated for extra overalls and laundering costs because of the widespread variation that is possible.

Local exhaust ventilation (LEV)

112. An HSE internal report (Cain, 1997) details costs associated with installing and running LEV systems and this report will be the basis for the costing. Costs will vary depending on the size and complexity of the motors, fans, air-cleaning and trunking, and whether a booth is required. Costs can range from about a capital cost of £2,000 for a small individual workstation up to capital costs of more than £50,000 for a large extraction booth. Running costs will be assumed to be 5% annually of the capital costs. In general we have assumed unit capital costs of £5,000 or £10,000 – depending on the nature of the industry.

113. In Annex 4, a summary of relevant processes is given. After reviewing the available exposure data (measured without assuming any abatement by RPE) and considering the results of a HSE survey conducted during 2003 (the results are summarised in Annex 5), estimates of the individual sector costs will be itemised.

114. All the costs in the following industry sections are based on the premise that after elimination and substitution of the hazardous material, the next control options are engineering. RPE is costed as a later resort but in practice, costs for extra RPE (both in the short term and in the long term) may be introduced at an earlier stage.

Foundry industry

Compliance costs.

115. From the 2003 HSE questionnaire (table 10, Annex 5), it was believed that currently 2% of employees were exposed to RCS levels above 0.3 mg.m^{-3} , about 4% were exposed to RCS levels above 0.1 mg.m^{-3} , about 11% were exposed to RCS levels above 0.05 mg.m^{-3} and about 18% were exposed to RCS levels above 0.01 mg.m^{-3} .

Compliance costs to the foundry industry for a RCS limit set at 0.3 mg.m^{-3} are derived as follows:-

116. Table 16, Annex 5 is a summary of the foundry industry's view on the costs of compliance with this limit, and they range from none to a £180,000 capital cost with £15,000 annual running costs per site.

117. Table 18, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Most believed that no extra controls would be required, although some mentioned air-hoods and improved extraction.

118. We believe that RCS exposures above 0.3 mg.m^{-3} are currently controlled by RPE.

119. Therefore we estimate that the compliance costs to the foundry industry for a RCS limit set at 0.3 mg.m^{-3} will be negligible.

120. Compliance costs to this industry sector for a RCS limit set at 0.1 mg.m^{-3} are derived as follows:-

121. Table 16, Annex 5 is a summary of the foundry industry's view on the costs of compliance with this limit, and they range widely from none to a £925,000 capital cost with £45,000 annual running costs per site. We believe this wide range reflects individual views rather than major differences between sites.

122. Table 18, Annex 5 summaries the industry's views on what controls would be needed to reduce RCS exposure to this limit. Some believed that no extra controls would be required, some suggested improved extraction and air-hoods, and one firm believed closure would be the only solution.

123. We believe that compliance with a new RCS exposure limit of 0.1 mg.m^{-3} would involve increased monitoring and some increased LEV costs. Based on an initial view of the CTI data collection exercise and examination of the 2003 HSE Questionnaire, we have assumed that 12% of the sites ($0.12 \times 300 = 36$ sites) would need extra monitoring annually at a cost of £1,000 (one day's consultant time and 10 samples analysed) per site, and that these sites would need extra engineering capital control costs of £10,000 per site with associated extra running costs of £500 per annum. This adds up to a capital cost of £360,000 in the first year and annual running costs of £54,000 per annum per site thereafter.

124. **Therefore we estimate that the compliance costs to the foundry industry for a RCS limit set at 0.1 mg.m⁻³ will be a capital cost of £360,000 and extra annual running costs of £54,000.**

125. **Compliance costs to this industry sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-**

126. Table 16, Annex 5 is a summary of the foundry industry's view on the costs of compliance with this limit, and they range from none to a £5 million capital cost per site.

127. Table 18, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Although a few believed no extra controls would be required, a range of improved controls were suggested, ranging from new extraction systems to completely new foundries.

128. We believe that compliance with a new RCS exposure limit of 0.05 mg.m⁻³ would involve much increased monitoring, extra LEV costs and extra RPE costs.

129. Based on an initial view of the CTI data collection exercise and examination of the 2003 HSE Questionnaire, we have assumed that 50% of sites (150 sites) would need extra monitoring annually at a cost of £1,000 (one day's consultant time and 10 samples analysed) per site, and that these sites would need extra engineering capital control costs of £10,000 per site with an associated extra running costs of £500 per annum (total capital cost of £1.5 million with annual running costs of £75,000), and extra RPE costs for 50% of these extra sites – or 25% of the total of 300 sites. This represents 75 sites and assuming an extra four employees per site need power assisted respirators, this adds up to an extra 300 employees. The extra RPE costs would be annual costs of between £690 and £1181 plus 100 hours (at £10 an hour) for training, cleaning and servicing – a total of between £1690 and 2181 per employee or costs of between £507,000 and £654,300 for 300 employees.

130. **Therefore we estimate that the total compliance costs to the foundry industry for a RCS exposure limit set at 0.05 mg.m⁻³ will be a capital cost of £1,500,000 and extra annual running costs of between £732,000 and £879,300.**

131. **Compliance costs to this industry sector for a RCS limit set at 0.01 mg.m⁻³ are derived as follows:-**

132. Table 16, Annex 5 is a summary of the foundry industry's view on the costs of compliance with this limit, and they range up to a £5 million capital cost, but many sites suggested that the increased costs would be inestimable.

133. Table 18, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. A few companies listed suggestions but many considered that this limit was impracticable and that closure would be their only option.

134. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either a massive investment in robotics with no guarantee of full

compliance a total reliance on air-fed respirators, or a virtually complete closure of the industry.

135. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m^{-3} , based on the costs for a limit set at 0.05 mg.m^{-3} plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning, servicing. This amounts to between an extra £41,743,000 and £53,870,700 annually for 24,700 employees.

136. Therefore we estimate that the hypothetical compliance costs to the foundry industry for a RCS limit set at 0.01 mg.m^{-3} will be an initial capital cost of £1,500,000 and extra annual costs of between £42,475,000 and £54,750,000.

137. Table (L) summarises the cost estimates for the foundry sector to comply with possible new RCS exposure limits.

Table L: Estimated compliance costs for the foundry industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m^{-3}	Nil	Nil	Nil
0.1 mg.m^{-3}	0.36	0.05	3.75
0.05 mg.m^{-3}	1.5	0.73 – 0.88	27.2-30.6
0.01 mg.m^{-3}	1.5	42.4 – 54.7	979.7-1,259.8

Ceramics industry

Compliance costs.

138. For the estimation of costs of compliance, we will use the HSE survey data of 1997. Compliance costs to this industry sector for a RCS limit set at 0.3 mg.m^{-3} are derived as follows:-

139. Table 20, Annex 5 is a summary of the ceramic industry's view on the costs of compliance with this limit, and they range from none to minimal per site.

140. Table 22, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Only one site suggested any more control and this was for a further survey.

141. We believe there will be no extra costs to the large potteries for a RCS limit set at 0.3 mg.m^{-3} . For 3% of the smaller potteries (about 1 site), there will be extra annual monitoring costs of £1000 (a day's consultant's time and the cost of taking and analysing 10 samples) per site and extra engineering capital control costs of £10,000 per site with associated extra running costs of £500 per annum.

142. **Therefore we estimate that the total compliance costs to the ceramics industry for a RCS limit set at 0.3 mg.m⁻³ will be a capital cost of £10,000 and extra annual running costs of £1,500.**

143. **Compliance costs to this industry sector for a RCS limit set at 0.1 mg.m⁻³ are derived as follows:-**

144. Because the HSE survey data of 1997 does not break down the RCS exposures into groups above and below 0.1 mg.m⁻³, we cannot use this data to estimate potential costs for a new limit set at 0.1 mg.m⁻³. The 2003 HSE questionnaire data will be used instead, but these sites are predominantly the larger ones, will have generally lower RCS exposures, and are therefore likely to underestimate the average costs involved. To allow for this, we have assumed that costs will be higher per site.

145. Table 20, Annex 5 is a summary of the ceramic industry's view on the costs of compliance with this limit, and they range from none to £50,000 capital and £5,000 annual running costs per site.

146. Table 22, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. An automated vacuum cleaning system was suggested along with new fettling hoods and dust collectors, but some sites believed no further controls would be necessary.

147. We believe that compliance with a new RCS exposure limit of 0.1 mg.m⁻³ would involve some increased monitoring and extra RPE costs.

148. For 1% of the potteries (about 1 site), there will be extra annual monitoring costs of £2000 (two day's consultant's time and the cost of taking and analysing 20 samples) per site and extra engineering capital control costs of £20,000 per site with associated extra running costs of £1,000 per annum. This adds up to capital cost of £20,000 in the first year and annual running costs of £3,000 per annum thereafter.

149. **Therefore we estimate that the compliance costs to the ceramics industry for a RCS limit set at 0.1 mg.m⁻³ will be a capital cost of £20,000 and extra annual running costs of £3,000.**

150. **Compliance costs to this industry sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-**

151. Because the HSE survey data of 1997 does not break down the RCS exposures into groups above and below 0.05 mg.m⁻³, we cannot use this data to estimate potential costs for a new limit set at 0.05 mg.m⁻³. The 2003 HSE questionnaire data will be used instead but these sites are predominantly the larger ones, will have generally lower RCS exposures, and are therefore likely to underestimate the average costs involved. To allow for this, we have assumed that costs per site will be higher.

152. Table 20, Annex 5 is a summary of the ceramic industry's view on the costs of compliance with this limit, and they range from none to £200,000 capital and £20,000 annual running costs per site.

153. Table 22, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. A range of improvements was suggested and only two sites considered their controls to be currently adequate.

154. We believe that compliance with a new RCS exposure limit of 0.05 mg.m^{-3} would involve increased monitoring and extra LEV costs. For 7% of the potteries (about 5 sites), there will be extra annual monitoring costs of £2000 (two day's consultant's time and the cost of taking and analysing 20 samples) per site and extra engineering capital control costs of £20,000 per site with an associated extra running costs of £2,000 per annum.

155. Therefore we estimate that the compliance costs to the ceramics industry for a RCS limit set at 0.05 mg.m^{-3} will be a capital cost of £100,000 and extra annual running costs of £15,000.

156. Compliance costs to this industry sector for a RCS limit set at 0.01 mg.m^{-3} are derived as follows:-

157. Because the HSE survey data of 1997 does not break down the RCS exposures into groups above and below 0.1 mg.m^{-3} , we cannot use this data to estimate potential costs for a new limit set at 0.1 mg.m^{-3} . If the 2003 HSE questionnaire data was used any conclusions would be based on these predominantly the larger ones where compliance is likely to be better.

158. Table 20, Annex 5 is a summary of the ceramic industry's view on the costs of compliance with this limit, and they range from none to "very substantial", with most sites reporting very large potential costs.

159. Table 22, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Wide ranges of extra controls are believed to be needed, and these included "miracles."

160. We believe that compliance with a new RCS exposure limit of 0.01 mg.m^{-3} would involve massive engineering costs that are difficult to quantify or the establishment of an all-encompassing RPE programme.

161. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m^{-3} , based on the costs for a limit set at 0.05 mg.m^{-3} plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning, servicing. This amounts to an extra annual cost of between £42,250,000 and £54,525,000 for 25,000 employees – making no allowance for current RPE usage.

162. Therefore we estimate that the hypothetical compliance costs to the ceramics industry for a RCS limit set at 0.01 mg.m^{-3} will be an initial capital cost of £100,000 plus extra annual running costs of between £42,265,000 and £54,540,000.

163. Table (M) summarises the cost estimates to the ceramics industry to comply with new possible RCS exposure limits.

Table M: Estimated Compliance costs summary for the ceramics industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m ⁻³	0.01	0.002	0.104
0.1 mg.m ⁻³	0.02	0.003	0.208
0.05 mg.m ⁻³	0.1	0.02	1.04
0.01 mg.m ⁻³	0.1	42.3 – 54.5	965.1-1,245.2

Brick manufacture and heavy clay

Compliance costs to the brick/heavy clay industry sector for a RCS limit set at 0.3 mg.m⁻³ are derived as follows:-

164. Table 24, Annex 5 is a summary of the brick/heavy clay industry's view on the costs of compliance with this limit, and they range from none to £195,000 capital with £25,000 extra annual running costs per site.

165. Table 26, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Views ranged from none to improved LEV and better and more frequent cleaning regimes.

166. We believe that for 0.4% of the 80 sites (1 site) – based on table 10, Annex 5 - there will be extra annual monitoring costs of £1000 (a day's consultant's time and the cost of taking and analysing 10 samples) per site and extra engineering capital control costs of £100,000 per site with an associated extra running costs of £15,000 per annum. This large extra cost is owing to the large areas involved and the large costs of multi-point vacuum systems. This adds up to a total capital cost of £100,000 in the first year and annual running costs of £6,000 per annum thereafter.

167. Therefore we estimate that the compliance costs to the brick manufacture and heavy clay industry for a RCS limit set at 0.3 mg.m⁻³ will be an initial capital cost of £100,000 and extra annual running costs of £6,000.

168. Compliance costs to this industry sector for a RCS limit set at 0.1 mg.m⁻³ are derived as follows:-

169. Table 24, Annex 5 is a summary of the brick/heavy clay industry's view on the costs of compliance with this limit, and they range from none to a £2.9 million capital cost with £475,000 extra annual running costs per site.

170. Table 26, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Views ranged from none to a range of improvements including better brick handling methods.

171. We believe that for 22% of the 80 sites (18 sites) – based on table 10, Annex 5 - there will be extra annual monitoring costs of £1000 (a day's consultant's time and

the cost of taking and analysing 10 samples) per site and extra engineering capital control costs of £100,000 per site with an associated extra running costs of £5,000 per annum. This large extra cost is owing to the large areas involved and the large costs of multi-point vacuum systems. This adds up to a total capital cost of £1,800,000 in the first year and annual running costs of £108,000 per annum thereafter.

172. Therefore we estimate that the compliance costs to the brick manufacture and heavy clay industry for a RCS limit set at 0.1 mg.m⁻³ will be a capital cost of £1.8 million and extra annual running costs of £108,000.

173. Compliance costs to this industry sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-

174. Table 24, Annex 5 is a summary of the brick/heavy clay industry's view on the costs of compliance with this limit, and they range from none to a £4 million capital cost with £500,000 extra annual running costs per site.

175. Table 26, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Views ranged from none to a wide range of improvements. Some sites doubted if it was achievable.

176. We believe that that for 72% of the 80 sites (58 sites) – based on Table 10, Annex 5 - there will be extra annual monitoring costs of £1000 (a day's consultant's time and the cost of taking and analysing 10 samples) per site and extra engineering capital control costs of £100,000 per site with an associated extra running costs of £5,000 per annum. This large extra cost is owing to the large areas involved and the large costs of multi-point vacuum systems. We also believe that at this limit there will be a need for much improved RPE. Assuming that half of the 72% of the total of 7,000 employees (5,040) would need extra power-assisted respirators, the annual costs for this would be £690 - £1181 plus 100 hours training, cleaning and servicing per employee (£1,000); a total of 0.5 x 0.72 x 7,000 x (1690 – 2181) or between £ 4,258,800 and £5,496,120 annually.

177. Therefore we estimate that the compliance costs to the brick manufacture and heavy clay industry for a RCS limit set at 0.05 mg.m⁻³ will be a total capital cost of £5,800,000 in the first year and extra annual running costs of between £4,606,800 and £5,844,120 thereafter. Compliance costs to this industry sector for a RCS limit set at 0.01 mg.m⁻³ are derived as follows:-

178. Table 24, Annex 5 is a summary of the brick/heavy clay industry's view on the costs of compliance with this limit, and no figures can be given because they are considered to be inestimatable or the limit is impossible.

179. Table 26, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. There were major doubts concerning the achievability of such a limit.

180. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either a massive investment in robotics with no guarantee of full

compliance, a total reliance on air-fed respirators, or a virtually complete closure of the industry.

181. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m⁻³, based on the costs for a limit set at 0.05 mg.m⁻³ plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning, servicing. This amounts to an extra annual cost of between £7,571,200 and £9,770,880 for 4,480 employees.

182. Therefore we estimate that the hypothetical compliance costs to the brick manufacture and heavy clay industry for a RCS limit set at 0.01 mg.m⁻³ will be an initial capital cost of £5,800,000 and extra annual running costs of between £7,919,200 and £10,118,880.

183. Table (N) summarises the cost estimates to the brick making and heavy clay sector to comply with new possible RCS exposure limits.

Table N Estimated compliance costs summary for the brick making and heavy clay industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m ⁻³	0.1	0.006	0.837
0.1 mg.m ⁻³	1.8	0.1	15.06
0.05 mg.m ⁻³	5.8	4.6 – 5.8	145.72-173.95
0.01 mg.m ⁻³	5.8	7.9 – 10.1	221.3-271.5

Quarry industry

184. This section considers only aggregates, materials such as surfacing materials and slate because these are considered to be large quantity, low-added value materials with minimal processing. Other materials such as silica flour differ in many respects and are therefore considered in other sections.

Compliance costs.

185. A large quarry company have produced estimates of costs if the silica limit is lowered. These were based on a telephone poll of many of their sites and it is subject to a large variation in individual assumptions. 85 sites were contacted and they suggested that lowering the limit to 0.05 mg.m⁻³ would have a total capital cost of £16.5 million and would mean about 21 redundancies. Lowering the limit to 0.01 mg.m⁻³ would have a total capital cost of £42 million and result in about 32 redundancies. If we apply these figures pro-rata to the industry as a whole (assuming 2,000 sites) this could mean a total capital cost of £388 million and 500 redundancies for a limit set at 0.05 mg.m⁻³, and a total capital cost of £988 million and 750 redundancies for a limit set at 0.01 mg.m⁻³.

186. Compliance costs to the quarry industry for a RCS limit set at 0.3 mg.m⁻³ are derived as follows:-

187. From the 2003 HSE questionnaire (table 10, Annex 5), it was believed that currently 0.6% of employees were exposed to RCS levels above 0.3 mg.m⁻³, about 3% were exposed to RCS levels above 0.1 mg.m⁻³, about 4% were exposed to RCS levels above 0.05 mg.m⁻³ and about 8% were exposed to RCS levels above 0.01 mg.m⁻³.

188. Table 12, Annex 5 is a summary of the quarry industry's view on the costs of compliance with this limit, and they range from none to a £750,000 capital cost with £90,000 annual running costs per site.

189. Table 14, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Most believed that no extra controls would be required, although air-fed respirators and improved extraction were mentioned by one site.

190. Although HSE's post-1997 data (Table 3 Annex 1) showed no RCS exposure data above 0.3 mg.m⁻³, based on the 2003 HSE questionnaire (Table 10, Annex 2) we believe that 0.6% of sites (12 sites) will show improved controls. Monitoring is already routine, but we anticipate that these 12 sites will need to increase annual monitoring (an extra days sampling and 10 analyses at a total cost of £1,000) to ensure compliance – a total cost of £12,000.

191. We estimate that the compliance costs to the quarry industry for a RCS exposure limit set at 0.3 mg.m⁻³ will be an extra annual cost of £12,000.

192. Compliance costs to the quarry industry sector for a RCS limit set at 0.1 mg.m³ are derived as follows:-

193. Table 12, Annex 5 is a summary of the quarry industry's view on the costs of compliance with this limit, and they range from none to a £7.5 million capital cost with £0.5 million annual running costs per site.

194. Table 14, Annex 5 summaries the industry's views on what controls would be needed to reduce RCS exposure to this limit. Although some believed no extra controls would be required, one site suggested the use of "air-helmets" would be needed and others believed more LEV would be needed.

195. Based on HSE's NEDB post-1997 data, (Table 3 Annex 1) we believe that 11% of sites (a total of 220 sites) will need to improve their controls.

196. We have calculated the mean cost per affected site as follows: one extra air-conditioned ventilated cab for a large drilling rig (£250,000) plus one extra refuge (£30,000), a total of £280,000 with extra annual running costs of £14,000.

197. Assuming a mean capital cost of £280,000 for each of these 220 sites, the total extra capital cost will be £61.6 million with extra annual running costs of £3.08 million.

198. Furthermore, we anticipate that these 220 sites will need to increase annual monitoring (an extra days sampling and 10 analyses at a total cost of £1,000) to ensure compliance – a total cost of £220,000.

199. Therefore we estimate that the compliance costs to the quarry industry for a RCS exposure limit set at 0.1 mg.m⁻³ will be a capital cost of £61.6 million with extra annual running costs of £3.3 million.

200. Compliance costs to this industry sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-

201. Table 12, Annex 5 is a summary of the quarry industry's view on the costs of compliance with this limit, and they range from none to a £17 million capital cost with £0.9 million annual running costs.

202. Table 14, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Although a few believed no extra controls would be required, a range of improved controls was suggested, and one site thought the limit was impractical in any case.

203. Based on HSE's NEDB post-1997 data, (Table 3, Annex 1) we believe that 58% of sites (a total of 1160 sites) will need to improve their controls.

204. We have calculated the mean cost per affected site as follows: one extra air-conditioned ventilated cab for a large drilling rig (£250,000) plus one extra refuge (£30,000), a total of £280,000 with extra annual running costs of £14,000.

205. Assuming a mean capital cost of £280,000 for these 1160 sites, the total extra capital cost will be £324.8 million with extra annual running costs of £16.24 million.

206. Furthermore, we anticipate that these 1160 sites will need to increase annual monitoring (an extra days sampling and 10 analyses at a total cost of £1,000) to ensure compliance – a total cost of £1,160,000.

207. Therefore we estimate that the compliance costs to the quarry industry for a RCS exposure limit set at 0.05 mg.m⁻³ will be a capital cost of £324.8 million with extra annual running costs of £17.4 million.

208. This figure is similar to the one estimated by a large quarry company who conducted their internal telephone poll which resulted in a pro-rata industry (assuming 2,000 sites) figure of capital costs of £388 million plus 500 redundancies for a limit set at 0.05 mg.m⁻³.

209. Compliance costs to this industry sector for a RCS limit set at 0.01 mg.m⁻³ are derived as follows:-

210. Table 12, Annex 5 is a summary of the quarry industry's view on the costs of compliance with this limit, and they range from none to a £50 million capital cost with £0.2 million annual running costs per site, with many companies stating that costs would be inestimable or that the limit would be impossible to achieve.

211. Table 14, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit. Only one respondent believed that no extra controls would be required, a few made a list of suggestions but the majority believed that this limit was impracticable and closure would be the only option.

212. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either a massive investment in robotics and remote working with no guarantee of full compliance, a total reliance on air-fed respirators, or a virtually complete closure of the industry.

213. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m⁻³, based on the costs for a limit set at 0.05 mg.m⁻³ plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning, servicing. This amounts to an extra annual cost of between £42,250,000 and £54,525,000 for 25,000 employees – making no allowance for current RPE usage. .

214. Therefore we estimate that the hypothetical compliance costs to the quarry industry for a RCS exposure limit set at 0.01 mg.m⁻³ will be an initial capital cost of £324.8 million and extra annual running costs of between £59,650,000 and £71,925,000.

215. Table (O) summarises the cost estimates for the quarry industry to comply with possible new RCS exposure limits.

Table O: Estimated Compliance costs summary for the quarry industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m ⁻³	Nil	0.0012	0.299
0.1 mg.m ⁻³	61.6	3.3	506.5
0.05 mg.m ⁻³	324.8	17.4	2,670.6
0.01 mg.m ⁻³	324.8	59.7 – 71.9	3,634.7-3,914.8

Slate quarries

Compliance costs

216. From the 2003 HSE questionnaire (Table 10, Annex 5), it was believed that currently all employees (35 employees were covered by the survey) were exposed to RCS levels between 0.1 and 0.3 mg.m⁻³. This may be optimistic rather than pessimistic.

217. Only one specific reply was received from the 2003 HSE questionnaire on the costs of compliance and the specific controls that would be needed, and no concern was expressed about a new limit of 0.1 mg.m⁻³. However, on follow-up, the company

had concerns following their most recent (2003) sampling exercise – discussed briefly under the section headed “exposure data.”

218. On this basis, we estimate that the compliance costs to the slate quarrying industry for a RCS exposure limit set at 0.3 mg.m⁻³ will be negligible.

219. Compliance costs to the slate quarrying industry sector for a RCS limit set at 0.1 mg.m⁻³ are derived as follows:-

220. We believe that a limit set at this level would necessitate an ongoing monitoring programme because the industry has little evidence available from current monitoring programmes of compliance (or non-compliance) with any 8-hour TWA limit. With an estimated 12 slate-splitting workshops in the UK, we assume that each site will need to be monitored annually at a cost of one consultant/sampler for one day (£500) and 10 samples (£500), a total of £12,000 for all sites. To reduce exposure to below 0.1 mg.m⁻³ will require more efficient LEV, additional LEV or LAD. We have assumed that each slate workshop will require 2 extra areas for a combined LEV/LAD system at a cost of £40,000 for each system. This will result in capital costs of £960,000 with extra annual running costs of £48,000.

221. Therefore we estimate that the compliance costs to the slate quarrying industry for a RCS exposure limit set at 0.1 mg.m⁻³ will be an initial capital cost of £960,000 and extra annual running costs of £60,000.

222. Compliance costs to the slate production industry sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-

223. We believe that a limit set at this level would necessitate an ongoing monitoring programme because the industry has little evidence available from current monitoring programmes of compliance (or non-compliance) with any 8-hour TWA limit. With an estimated 12 slate-splitting workshops in the UK, we assume that each site will need to be monitored annually at a cost of one consultant/sampler for one day (£500) and 10 samples (£500), a total of £12,000 for all sites.

224. To reduce exposure to below 0.05 mg.m⁻³ will require more efficient LEV, additional LEV and LAD.

225. We have assumed that each slate workshop will require an extra two areas for a combined LEV/LAD system at a cost of £40,000 for each system. This will result in capital costs of £960,000 with extra annual running costs of £48,000.

226. There will also be the need for some employees to wear powered respirators at a cost of between £690 - £1181 annually, plus 100 hours (at £10 an hour) for training, cleaning and servicing. This will result in an extra annual cost of between £1691 and £2181 per employee affected. We assume that five employees per on-site workshop will be involved at a total extra annual cost for 5 x 12 = 60 employees of between £101,400 and £130,860.

227. Therefore we estimate that the total compliance costs to the slate quarrying industry for a RCS exposure limit set at 0.05 mg.m⁻³ will be an initial

capital cost of £960,000 with extra annual running costs of £161,400 and £190,860.

228. **Compliance costs to the slate production industry sector for a RCS limit set at 0.01 mg.m⁻³ are derived as follows:-**

229. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either a massive investment in robotics with no guarantee of full compliance, the use of air-fed respirators as a routine requirement, a total reliance on air-fed respirators, or a virtually complete closure of the industry.

230. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m⁻³, based on the costs for a limit set at 0.05 mg.m⁻³ plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning, servicing. This amounts to an extra annual running cost of between £1,588,600 and £2,050,140 for an extra 940 employees (all those not already accounted for at a limit of 0.05 mg.m⁻³).

231. **Therefore we estimate that the hypothetical compliance costs to the slate quarrying industry for a RCS exposure limit set at 0.01 mg.m⁻³ will be an initial capital cost of £960,000 and extra annual running costs of between £1,750,000 and £2,241,000.**

232. Table (P) summarises the cost estimates for the slate splitting sector to comply with possible new RCS exposure limits.

Table P: Estimated compliance costs summary for the slate-splitting industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m ⁻³	Nil	Nil	Nil
0.1 mg.m ⁻³	0.96	0.048	8.09
0.05 mg.m ⁻³	0.96	0.161 – 0.191	10.4-11.1
0.01 mg.m ⁻³	0.96	1.75 – 2.24	46.7-57.9

Industrial minerals

233. These are lower quantity, high added value processed materials. The section is split into four to reflect the different sectors of silica sand production, silica flour production, specialist industrial mineral production (such as potash, gypsum and limestone) and the usage of industrial mineral products.

Silica sand production

Silica sand quarrying

Compliance costs

234. The European Association of Industrial Silica Producers (EUROSIL) recently (2003) distributed a questionnaire to its members concerning the costs of complying with potential new silica limits of 0.1, 0.05 and 0.01 mg.m⁻³. As this data includes responses from most of the UK companies, this information is used to estimate the costs for this sector.

235. Compliance costs to the silica sand quarrying industry for a RCS limit set at 0.3 mg.m⁻³ are derived as follows:-

236. We believe that there will be no extra costs for a RCS limit set at 0.3 mg.m⁻³.

237. Compliance costs to the silica sand quarrying industry for a RCS limit set at 0.1 mg.m⁻³ are derived as follows:-

238. 6 companies (operating 16 of the estimated 25 sites) returned the EUROSIL questionnaire and the total estimated capital costs to comply with a RCS limit of 0.1 mg.m⁻³ were £652,000. Applying these costs pro-rata to all sites, we estimate there will be an increased capital cost of £1 million (and therefore extra annual running costs of £50,000).

239. Based on HSE's NEDB post-1997 data for the quarry industry as a whole (Table 3, Annex 1), we believe that 11% of sites (3 sites) will need to increase annual monitoring (an extra days sampling and 10 analyses at a total cost of £1,000 per site) to ensure compliance – a total cost of £3,000 annually.

240. Therefore we believe that the compliance costs to the silica sand quarrying industry for a RCS exposure limit set at 0.1 mg.m⁻³ will be an extra capital cost of £1,000,000 and extra annual running costs of £53,000.

241. Compliance costs to the silica sand quarrying industry for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-

242. 6 companies (operating 16 of the estimated 25 sites) returned the EUROSIL questionnaire and the total estimated capital cost to comply with a RCS limit of 0.1 mg.m⁻³ was £1.9 million. Applying these costs pro-rata to all companies, we estimate there will be an increased capital cost of £3, 000,000 (and therefore extra annual running costs of £150,000).

243. Based on HSE's NEDB post-1997 data for the quarry industry as a whole (Table 3, Annex 1), we believe that 58% of sites (15 sites) will need to increase annual monitoring (an extra days sampling and 10 analyses at a total cost of £1,000 per site) to ensure compliance – a total cost of £15,000 annually.

244. Therefore we believe that the compliance costs to the silica sand quarrying industry for a RCS exposure limit set at 0.05 mg.m⁻³ will be an extra capital cost of £3,000,000 and extra annual running costs of £165,000.

245. Compliance costs to the silica sand quarrying industry for a RCS limit set at 0.01 mg.m⁻³ are derived as follows:-

246. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either a massive investment in robotics and remote working with no

guarantee of full compliance, a total reliance on air-fed respirators, or a virtually complete closure of the industry.

247. However, we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m⁻³, based on the costs for a limit set at 0.05 mg.m⁻³ plus every potentially exposed employee (500) wearing a power-assisted respirator at annual costs of between £690 - £1181 plus an extra 11 hours (£1,000) for training, cleaning and servicing. This amounts to an extra annual cost of between £845,000 and £1,090,500.

248. Therefore we believe that the compliance costs to the silica sand quarrying industry for a RCS exposure limit set at 0.01 mg.m⁻³ will be an extra capital cost of £3,000,000 and extra annual running costs between £1,010,000 and £1,255,500

Table Q: Estimated compliance costs summary for the silica sand quarrying industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m ⁻³	Nil	Nil	Nil
0.1 mg.m ⁻³	1.0	0.053	8.2
0.05 mg.m ⁻³	3.0	0.165	24.8
0.01 mg.m ⁻³	3.0	1.01 – 1.26	44.05-49.65

Underground mining of silica sand

Silica sand is mined underground at one site in the UK.

Compliance costs

249. We have not attempted to estimate compliance costs for this site alone, on the assumption that the costs are part of that already estimated for the silica sand production industry.

Silica flour production

Compliance costs

250. Two quarrying companies producing silica flour have estimated potential costs at their production sites. Both companies predicted that it would be impossible to comply with an RCS limit set at 0.01 mg.m⁻³.

Company 1

251. This company concluded that RCS limits set at 0.05 mg.m⁻³ or 0.1 mg.m⁻³ could necessitate similar capital costs for compliance. This similarity is due to the fact that it is only possible to test the effectiveness of dust control measures once they have

been implemented. Exposure levels at this company are currently in the region of 0.3 mg.m^{-3} so all reasonably practicable control measures would need to be taken to reduce exposures to comply with a limit of 0.1 mg.m^{-3} , and any further reduction in the RCS limit would have to be dealt with by extra use of RPE for specific dusty tasks which would necessitate increased running costs.

252. The option of improving the present system by automated bag placing, shrink wrapping, new bagging heads and extending the warehouse would be costly with no guarantee of successfully complying with limits below 0.1 mg.m^{-3} .

253. Full automation of the bagging plant would involve a capital cost of £1.8 million. One alternative, a move to bulk bagging, would involve a capital cost of £210k but would mean £25k capital costs at every customer's site. Another alternative, a move to bulk transport, would cost each customer about £80k for the construction of a silo, a conveyor and weigh cells. These alternatives would produce savings in the long term because of reduced labour costs but these are difficult to quantify. However, the majority of customers take only small quantities of silica flour each year so supply in bulk would only be workable for a limited number of larger customers.

254. The construction of a new mill might also be required at this site at a capital cost of £6 million. If an additional mill were to be installed, this would allow for engineering work to be better phased so as to reduce personal exposure levels during maintenance tasks.

255. Partial improvements to the current milling system have been calculated separately by this company and are itemised below. Consideration is given to reducing emissions of silica dust and to reducing maintenance work since both have an influence on personal RCS exposure

256. The fitting of alumina linings to pipework would significantly reduce the amount of maintenance work required to repair damage caused by the abrasive nature of the product and would reduce leakage of RCS through holed pipework. This would have a capital cost of £300k. Partial automation by way of automatic sampling, telemetry, CCTV and automated media addition would have a capital cost of about at least £300k. Full automation would include all the costs of partial automation and add costs to motorise existing controls, and to fit new bag filters with an increased filtration area (giving longer service life and reduced maintenance) would come to a total capital cost of £250k. Minor savings in maintenance costs would accompany the reduction in maintenance requirements.

257. There would also be costs associated with improving general ventilation with the addition of extra fans in the roof and the removal of top cladding to facilitate thermal venting (a total capital cost of £60k) should these modifications be approved under local planning rules. The adoption of wet cleaning processes (to replace dry vacuuming) could be achieved by the installation of corrosion-resistant aluminium flooring, or by laying a bitumen coating on the existing steel floors, but this could add another £1 million capital cost and would require further expenditure to upgrade electrical equipment to prevent water damage. The replacement of a rotary cooler with air slides and the replacement of a rotary dryer with a fluid bed system would add another £330k of capital cost. Alternatives to the current wet scrubber to reduce

maintenance requirements (stand-alone bag filter unit and a connection to the kiln bag filter unit) could cost £200k more.

258. Transport changes would also be required to comply with a new RCS limit. The fitting of rotary airlocks, new screw conveyors, new venting lines, dust control units, and new lorry loading chutes would have a capital cost of just under £300k but effectiveness may be limited by size and space considerations.

259. There might also be a need to improve the kiln operations and the in-plant QC operations at a total capital cost of about £300k.

Company 2

260. Personal exposure levels to RCS in this company are already around 0.1 mg.m⁻³. Compliance with a limit of 0.1 mg.m⁻³ would require about £300,000 of capital expenditure on automated bagging plant. Operating costs would be increased by £50,000 a year.

261. For this company, a reduction of the RCS limit to 0.05 mg.m⁻³ would result in the need for capital expenditure of £2 million to £3 million (to cover full automation and enclosure of the plant and the provision of extra LEV systems) plus an increase in operating costs of £100,000.

262. Compliance costs to the silica flour production sector for a RCS limit set at 0.3 mg.m⁻³ are derived as follows:-

263. Although some RCS exposures are currently above 0.3 mg.m⁻³, these are ameliorated by the use of RPE where necessary. The sites are few in number and the risks are well known, **therefore we estimate that the compliance costs to the silica flour production industry for a RCS exposure limit set at 0.3 mg.m⁻³ will be negligible.**

264. Compliance costs to the silica flour production sector for a RCS limit set at 0.1 mg.m⁻³ are derived as follows:-

265. Based on the supplied industry data, Table 7 Annex 1, where 80% of the RCS values were over 0.1 mg.m⁻³, we believe that one option needed would be full automation of the bagging area. This would cost £1.8 million at one site and if this were similar at the other two sites the total capital cost would be £5.4 million. However, we believe from the industry that a better estimate will be obtained by assuming that the total capital cost should be the estimate of company 1 plus twice the estimate of company 2. This total capital cost would therefore be £1.8 million plus 2 x £300,000, or £2.4 million.

266. Improvements would also be needed in the milling and transport areas for company 1. We believe that capital costs could be as much as an extra £2.5 million at company 1 alone. Total capital costs for the sector will therefore be £4.9 million.

267. There will be extra running costs at these companies because of the automated bagging area and our estimate is an extra annual cost of 5% or £245,000.

268. Therefore we estimate that the compliance costs to the silica flour production industry for a RCS exposure limit set at 0.1 mg.m⁻³ will be a capital cost of £4.9 million with extra annual running costs of £245,000.

269. Compliance costs to the silica flour production sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-

270. Based on the supplied industry data, Table7 Annex 1, where 80% of the RCS values were over 0.1 mg.m⁻³, we believe that one option needed would be full automation of the bagging area. This would cost £1.8 million at company 1 alone. Improvements would also be needed in the milling and transport areas of company 1 and these could amount to £2.5 million. For the other two companies, we believe that the total capital costs will be £5 million, making a total for the sector of £9,300,000. Extra annual running costs would total £465,000.

271. Therefore we estimate that the compliance costs to the silica flour production industry for a RCS exposure limit set at 0.05 mg.m⁻³ will be a capital cost of £9,300,000 with extra annual running costs of £465,000.

272. Compliance costs to the silica flour production sector for a RCS limit set at 0.01 mg.m⁻³ are derived as follows:-

273. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either a massive investment with no guarantee of full compliance, a total reliance on air-fed respirators, or a virtually complete closure of the industry.

274. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m⁻³, based on the costs for a limit set at 0.05 mg.m⁻³ plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning, servicing. This amounts to extra annual RPE running costs of between £67,600 and £87,240 for an estimated 40 employees – taking no account of current RPE usage.

275. Therefore we estimate that the hypothetical compliance costs to the silica sand/flour production industry for a RCS limit set at 0.01 mg.m⁻³ will be an initial capital cost of £9,300,000 and extra annual running costs of between £532,600 and £552,240.

276. Table (R) summarises the cost estimates to the silica flour production sector for compliance with new possible RCS exposure limits.

Table R: Estimates of compliance costs for the silica flour production sector

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m ⁻³	Nil	Nil	Nil
0.1 mg.m ⁻³	4.9	0.25	39.89
0.05 mg.m ⁻³	9.3	0.47	75.7

0.01 mg.m ⁻³	9.3	0.533 – 1.552	77.3-77.7
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Usage of silica-containing industrial minerals

Compliance costs.

277. The road-marking sector was asked for an estimate of potential costs. They believed that although a limit set at 0.1 mg.m⁻³ could be complied with, any limit around 0.05 mg.m⁻³ would necessitate considerably more risk assessments and routine monitoring. A limit set around 0.01 mg.m⁻³ would mean total substitution and the loss of export markets.

278. In the glass-polishing sector, the current MEL of 0.3 mg.m⁻³ was achieved comfortably but a limit for RCS set at 0.1 mg.m⁻³ would mean a greater reliance on disposable overalls and an extracted changing area. A limit set below 0.1 mg.m⁻³ would necessitate the regular use of RPE also.

279. Compliance costs to this industry sector for a RCS limit set at 0.3 mg.m⁻³ are derived as follows:-

280. With no reliable data, the true costs are difficult to establish but exposures above 0.3 mg.m⁻³ seem to be ameliorated by RPE. **Therefore, we believe that the compliance costs to the silica sand/flour uses industry for a RCS exposure limit set at 0.3 mg.m⁻³ will be negligible.**

281. Compliance costs to this industry sector for a RCS limit set at 0.1 mg.m⁻³ are derived as follows:-

282. We believe that there will be no extra costs in the composites, road-marking, floors and coatings, jewellery casting and miscellaneous uses of silica and/flour sectors. However, information in these areas is sparse.

283. In the production of scouring powders, the purchase of bag-balers is essential to reduce RCS exposure from bag disposal. Assuming there are 10 sites, this will cost a total of 10 x £5000 = £50,000 with no extra annual running costs. We have also assumed one extra extracted booth for bag splitting at a cost of £10,000 per site – a total of £100,000 with extra annual running costs of £5,000. For a limit set at 0.1 mg.m⁻³, we believe there will be a need for extra monitoring and we have assumed an extra annual cost of £1,000 (£500 for a consultant and £500 for the collection and analysis of 10 samples) per site.

284. In the glass polishing industry, monitoring is routinely carried out but we believe that a new RCS limit set at 0.1 mg.m⁻³ will mean more regular monitoring will be needed. We believe that an extra monitoring session every other year will be needed at a cost of £1,000 (£500 for a consultant day and £500 for the collection and analysis of 10 samples) per session. We have also assumed that there will be an extra cost for an extracted changing room at a capital cost of £30,000 and extra annual running costs of £1,500.

285. **Therefore we estimate that the compliance costs to the silica sand/flour uses industry for a RCS exposure limit set at 0.1 mg.m⁻³ will be extra capital cost of £180,000 and extra alternating annual running costs of £16,500 and £17,500.**

286. **Compliance costs to this industry sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-**

287. We believe that there will be no extra costs in the road marking, floors and coatings and miscellaneous sector. However, information in these areas is sparse.

288. In the production of scouring powders, the purchase of bag-balers is essential to reduce RCS exposure from bag disposal. Assuming there are 10 sites, this will cost a total of 10 x £5000 = £50,000 with no extra annual running costs. We have also assumed one extra extracted booth for bag splitting at a cost of £10,000 per site – a total of £100,000 with extra annual running costs of £5,000. For a limit set at 0.05 mg.m⁻³, we believe there will be a need for extra monitoring and we have assumed an extra annual cost of £1,000 (£500 for a consultant and £500 for the collection and analysis of 10 samples) per site. We have also assumed that two extra power-assisted respirators will be required per site at annual costs of between £690 - £1181 plus 100 (at £10 an hour) hours training, cleaning and servicing for an annual cost of between £3,380 and £4,362 per site.

289. In the composites sector, we believe there will be a need for annual monitoring (£500 for a consultant and £500 for the collection and analysis of 10 samples) at the estimated 20 sites, making a total of £20,000. We have assumed that there will be a need for extra LEV during the mixing of silica flour to the other materials of the composites at a cost of £10,000 per site, making a total capital cost of £200,000 with extra annual running costs of £10,000.

290. In the jewellery-casting sector, we believe there will be a need for annual monitoring (£500 for a consultant and £500 for the collection and analysis of 10 samples) at the estimated 200 sites, making a total of £200,000. We have assumed that there will be a need for extra LEV during the mixing of the moulding powder at a cost of £10,000 per site, making a total capital cost of £2 million with extra annual running costs of £100,000. We have also assumed that two extra power-assisted respirators will be required per site at annual costs of between £690 - £1181 plus 100 (at £10 an hour) hours training, cleaning and servicing for an annual cost of between £3,380 and £4,362 per site – a total RPE annual cost (for 200 sites) of between £676,000 and £872,400

291. In the glass polishing industry, monitoring is routinely carried out but we believe that a new RCS limit set at 0.5 mg.m⁻³ will mean more regular monitoring will be needed. We believe that an extra monitoring session every other year will be needed at a cost of £1,000 (£500 for a consultant day and £500 for the collection and analysis of 10 samples) per session. We have also assumed that there will be an extra cost for an extracted changing room at a capital cost of £30,000 with extra annual running costs of £1,500.

292. **Therefore we estimate that the compliance costs to the silica sand/flour uses industry for a RCS exposure limit set at 0.05 mg.m⁻³ will be a capital cost**

of £2,380,000 with extra annual running costs of between £1,056,300 (£1,057,300) and £1,262,520 (£1,263,520). The figures in brackets include the glass industry monitoring costs, which occur every other year.

293. **Compliance costs to the silica sand/flour uses sector for a RCS limit set at 0.01 mg.m⁻³ are derived as follows:-**

294. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either massive investments with no guarantee of full compliance, a total reliance on air-fed respirators, or a virtually complete closure of the industries.

295. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m⁻³, based on the costs for a limit set at 0.05 mg.m⁻³ plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning, servicing. This amounts to extra annual running costs of between £4,225,000 and £5,452,500 for an extra 2,500 employees – making no allowance for current RPE usage.

296. **Therefore we estimate that the hypothetical compliance costs to the silica sand/flour uses industry for a RCS limit set at 0.01 mg.m⁻³ will be an initial capital cost of £2,380,000 and extra annual running costs of between £4,605,300 (£4,606,300) and £5,842,620 (£5,843,620).**

297. Table (S) summarises the cost estimates to the silica sand/flour uses industry to comply with possible new RCS exposure limits.

Table S: Estimated compliance costs summary for the silica sand/flour uses industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m ⁻³	Nil	Nil	Nil
0.1 mg.m ⁻³	0.18	0.017	1.636-1.659
0.05 mg.m ⁻³	2.38	1.057 – 1.264	40.76-45.49
0.01 mg.m ⁻³	2.38	4.606 – 5.844	121.7-150.0

Construction industry

Cost of compliance

298. This sector is the most difficult in which to quantify costs because there are a wide range of differing activities which can create respirable crystalline silica and for which daily routines are so variable. Much of the exposure data is task-based, and acute exposure may be a poor surrogate for day-on-day chronic exposure. However, it is clear that certain tasks, even when carried out intermittently, have the potential for high RCS exposure.

299. From the few replies to the 2003 HSE questionnaire (table 10, Annex 5) by the construction industry sector, 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} . Such optimism may be based on ignorance because routine monitoring is rare in this industry

300. Compliance costs to this industry sector for a RCS limit set at 0.3 mg.m^{-3} are derived as follows:-

301. Table 28, Annex 5 is a summary of the construction industry's view on the costs of compliance with this limit, and no companies believed that there would be any extra costs.

302. Therefore we estimate that the compliance costs to the construction industry for a RCS limit set at 0.3 mg.m^{-3} will be negligible.

303. Compliance costs to this industry sector for a RCS limit set at 0.1 mg.m^{-3} are derived as follows:-

304. Table 28, Annex 5 is a summary of the construction industry's view on the costs of compliance with this limit, and they range from none to between an extra £2,000 and £5,000 capital annual running costs per site. However, these responses are from very few sites.

305. We believe that there will be extra costs to the construction sector if a new RCS limit is set at this level.

306. The cutting of concrete blocks and kerbstones is a regular task on many sites and not every cutter has water suppression. The number of employees cutting kerbstones daily is very difficult to estimate but we have assumed 5,000 (based on the assumption that there are about 150 companies with between 1 and 100 employees involved in this work with most firms being small. The full time cutters are responsible for between 50% and 75% of the total work with the rest being done by casual workers who hire their equipment on a short-term basis), of which 20% will need increased controls to comply with a RCS limit set at 0.1 mg.m^{-3} . At a unit cost of around £200 annually for fitted extraction or water suppression, this will total extra capital costs of $1000 \times 200 = \text{£}200,000$ with extra annual running costs of £10,000.

307. We believe that power assisted respirators with eye protection will need to be used for many jobs that currently are done without. These have annual costs of between £690 - £1181 plus 100 hours (at £10 per hour) training, cleaning and servicing per employee. Assuming that 1,000 employees will need to use these respirators regularly, this will cost a total of between £1.69 million and £2.181 million annually.

308. We acknowledge that there may be extra costs to other parts of the construction industry that we have not included.

309. **Therefore we estimate that the compliance costs to the construction industry for a RCS exposure limit set at 0.1 mg.m⁻³ will be a capital cost of £200,000 and extra annual running costs of between £1,700,000m and £2,191,000m.**

310. **Compliance costs to the construction industry sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-**

311. Table 28, Annex 5 is a summary of the construction industry's view on the costs of compliance with this limit, and they range from none to between an extra £2,000 and £5,000 capital annual running costs per site. However, these responses are from very few sites and are not considered a reliable estimate.

312. We believe that there will be extra costs to the construction sector if a new RCS limit is set at this level. We believe that a limit set at this level would necessitate a continuous monitoring programme because the industry has little evidence available from current monitoring programmes of compliance (or non-compliance) with any 8 hour TWA limit. We have assumed that around 1,000 sites will need annual monitoring at a cost of £1,000 (£500 for a consultant and the collection and analysis of 10 samples at a cost of £500). This will produce extra annual monitoring costs of £1 million.

313. The cutting of concrete blocks and kerbstones is a regular task on many sites and not every cutter has water suppression. The number of employees cutting kerbstones daily is very difficult to estimate but we have assumed 5,000 (based on the assumption that there are about 150 companies with between 1 and 100 employees involved in this work with most firms being small. The full time cutters are responsible for between 50% and 75% of the total work (with the rest being done by casual workers who hire their equipment on a short-term basis), of which 50% will need increased controls to comply with a RCS limit set at 0.05 mg.m⁻³. At a unit cost of around £200 annually for fitted extraction or water suppression, this will total capital costs of 2,500 x 200 = £500,000, with extra annual running costs of £25,000.

314. We believe that power assisted respirators will need to be used for many jobs that currently are done without. These have annual costs of between £690 - £1181 plus 100 hours (at £10 per hour) training, cleaning and servicing per employee. Assuming that 10,000 employees will need to use these respirators regularly, this will cost a total of between £16.9 million and £21.81 million annually.

315. In construction drilling and cutting, the industry believes that a limit set much below 0.1 mg.m⁻³ may necessitate major changes in that full-time drillers and cutters, who use water suppression routinely will have to be employed more frequently to ensure RCS exposure is adequately controlled. This will add an indeterminate amount to overall costs.

316. We acknowledge that there may be extra costs to other parts of the construction industry that we have not included.

317. **Therefore we estimate that the compliance costs to the construction industry for a RCS exposure limit set at 0.05 mg.m⁻³ will be a capital cost of £500,000 and extra annual running costs of £17,925,000m and £22,835,000m.**

318. **Compliance costs to this industry sector for a RCS limit set at 0.01 mg.m⁻³ are assumed to be as follows:-**

319. Table 28, Annex 5 is a summary of the construction industry's view on the costs of compliance with this limit, and they range from none to between an extra £2,000 and £5,000 annual running costs per site. However, these responses are from very few sites and may be a result of hope rather than experience.

320. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either a massive investment in efficient RPE with no guarantee of full compliance, a total reliance on air-fed respirators, or a virtually complete closure of the industry.

321. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m⁻³, based on the costs for a limit set at 0.05 mg.m⁻³ plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning, servicing. This amounts to extra costs of between £236,600,000 and £305,340,000 for an assumed extra 140,000 employees.

322. Therefore we estimate that the hypothetical compliance costs to the construction industry for a RCS exposure limit set at 0.01 mg.m⁻³ will be an initial capital cost of £500,000 and extra annual running costs of between £254,525,000 and £328,175,000.

333. Table (T) summarises the cost estimates for the construction industry to comply with new possible RCS exposure limits.

Table T: Estimated compliance costs summary for the construction industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60year extra costs (£ million)
0.3 mg.m ⁻³	Nil	Nil	Nil
0.1 mg.m ⁻³	0.2	1.7 - 2.2	40.19-51.4
0.05 mg.m ⁻³	0.5	17.9 –22.8	412.5-524.6
0.01 mg.m ⁻³	0.5	254.5 – 328.2	5,811.4 - 7,491.9

Stonemasonry industry

Cost of compliance

334. From the 2003 HSE questionnaire (Table 10, Annex 5), it was believed that currently no employees were exposed to RCS levels above 0.3 mg.m⁻³, none were exposed to RCS levels above 0.1 mg.m⁻³, none were exposed to RCS levels above 0.05 mg.m⁻³ and about 2% were exposed to RCS levels above 0.01 mg.m⁻³. However, the number of respondents was low and HSE believes that there are RCS exposures above 0.3 mg.m⁻³.

335. Compliance costs to the stonemasonry industry sector for a RCS limit set at 0.3 mg.m⁻³ are derived as follows:-

336. Table 31, Annex 5 is a summary of the stonemasonry industry's view on the costs of compliance with this limit, and no extra costs were thought likely.

337. Table 33, Annex 5 summarises the stonemasonry industry's views on what controls would be needed to reduce RCS exposure to this limit, and none were expected.

338. We believe there are RCS exposures above 0.3 mg.m⁻³, but some of these are ameliorated by the use of RPE. We assume that to comply with an RCS limit set at 0.3 mg.m⁻³, there will be a need for the installation of downdraught extraction for hand tools, plus increased use of wet cutters and polishers will be needed at some sites. We have assumed that 5% of the exposed employees (a total of 100) will need to spend about £2,000 on better extraction at a total cost of £200,000 with extra annual running costs of £10,000.

339. Therefore we believe that total costs for the stonemasonry sector to comply with a new RCS limit set at 0.3 mg.m⁻³ are extra capital costs of £200,000 with extra annual running costs of £10,000.

340. Compliance costs to this industry sector for a RCS limit set at 0.1 mg.m⁻³ are derived as follows:-

341. Table 31, Annex 5 is a summary of the stonemasonry industry's view on the costs of compliance with this limit and no costs were anticipated.

342. Table 33, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit, and none were expected.

343. We believe that there will be extra costs associated with a RCS exposure limit set at 0.1 mg.m⁻³.

344. We believe that a limit set at this level would necessitate a continuous monitoring programme because the industry has little evidence available from current monitoring programmes of compliance (or non-compliance) with any 8-hour TWA limit. We have assumed that 20% of all exposed employees (400) will need annual monitoring at a cost of £1,000 (£500 for a consultant and the collection and analysis of 10 samples at a cost of £500). This will produce extra annual monitoring costs of £400,000.

345. The installation of downdraught extraction for hand tools, plus increased use of wet cutters and polishers will be needed at some sites. We have assumed that 10% of the exposed employees (a total of 200) will need to spend about £2,000 on better extraction at a total cost of £400,000 with extra annual running costs of £20,000.

346. Therefore we estimate that the compliance costs to the stonemasonry industry for a RCS exposure limit set at 0.1 mg.m⁻³ will be a capital cost of £400,000 and extra annual running costs of £420,000.

347. Compliance costs to this industry sector for a RCS limit set at 0.05 mg.m⁻³ are derived as follows:-

348. Table 31, Annex 5 is a summary of the stonemasonry industry's view on the costs of compliance with this limit, and no definite views were given.

349. Table 33, Annex 5 summarises the stonemasonry industry's views on what controls would be needed to reduce RCS exposure to this limit, and none were expected.

350. We believe that there will be extra costs to the stonemasonry sector if a new RCS limit is set at 0.05 mg.m⁻³. We believe that a limit set at this level would necessitate a continuous monitoring programme because the industry has little evidence available from current monitoring programmes of compliance (or non-compliance) with any 8 hour TWA limit. We have assumed that around 50% of exposed employees (1000) will need annual monitoring at a cost of £1,000 (£500 for a consultant and the collection and analysis of 10 samples at a cost of £500). This will produce extra annual monitoring costs of £1,000,000.

351. The installation of booths will be required for about 10% of the employees (a total of about 200) at a capital cost of £10,000 each - a total cost of £2 million with extra annual running costs of £100,000.

352. For a further 10% (200) of the employees, down-draught extraction for hand tools, plus increased use of wet cutters and polishers will be needed. This works out at a cost of £400,000 with extra annual running costs of £20,000.

353. Therefore we estimate that the compliance costs to the stonemasonry industry for a RCS exposure limit set at 0.05 mg.m⁻³ will be a capital cost of £2,400,000 with extra annual running costs of £1,120,000.

354. Compliance costs to this industry sector for a RCS limit set at 0.01 mg.m⁻³ are derived as follows:-

355. Table 31, Annex 5 is a summary of the stonemasonry industry's view on the costs of compliance with this limit, and they ranged up to a capital cost of £15,000 with an annual running cost of £600 per site. However the number of respondents was low.

356. Table 33, Annex 5 summarises the industry's views on what controls would be needed to reduce RCS exposure to this limit, and replacement LEV and new working methods were suggested.

357. We believe that compliance with a new RCS exposure limit of 0.01 mg.m⁻³ would involve either a massive investment in robotics with no guarantee of full compliance, a total reliance on air-fed respirators or a virtually complete closure of the industry.

358. However we can estimate hypothetical costs for an RCS exposure limit set at 0.01 mg.m⁻³, based on the costs for a limit set at 0.05 mg.m⁻³ plus every potentially exposed employee wearing a power assisted respirator at extra annual costs of between £690 - £1181 plus an extra 100 hours (£1,000) for training, cleaning,

servicing. These amount to extra annual running costs of between £3,380,000 and £4,362,000 for 2,000 exposed employees, but makes no allowance for current RPE usage.

359. Therefore we estimate that the hypothetical compliance costs to the stone masonry industry for a RCS limit set at 0.01 mg.m⁻³ will be a capital cost of £2,400,000 with extra annual running costs of between £4,500,000 and £5,482,000.

Compliance costs summary for the stonemasonry industry

360. Table (U) summarises the cost estimates for compliance with new possible RCS exposure limits.

Table U: Estimated Compliance costs summary for the stonemasonry industry

New RCS exposure limit	Initial capital costs (£ million)	New extra annual running costs (£ million)	Total 60 year extra costs (£ million)
0.3 mg.m ⁻³	0.2	0.01	1.63
0.1 mg.m ⁻³	0.4	0.42	12.38
0.05 mg.m ⁻³	2.4	1.12	42.36
0.01 mg.m ⁻³	2.4	4.50 – 5.48	119.5 -141.9

Costs to HSE

361. Although the costs of enforcing the limits, particularly the lower ones, are expected to be significant, HSE anticipates that enforcement costs would have to be absorbed within existing budgets. Although this would almost mean a re-allocation of resources, the subsequent opportunity costs are not readily quantifiable. HSE also proposes to bid for a programme of exposure sampling to monitor the impact of a new limit. Subject to confirmation of this bid, the programme may cost £100,000 a year over a five-year period. The present value of this is £470,000.

7. BALANCE OF COSTS AND BENEFITS

Table V: Costs and Benefits to Society Over Sixty Years (in present values)

	0.3mg/m ³	0.1mg/m ³	0.05mg/m ³	0.01mg/m ³
	£million	£million	£million	£million
Total Costs	5.1 to 5.3	638 to 650	3453 to 3603	12024 to 14663
Total Benefits	39.4 to 78.8	209. to 414	340 to 671	515 to 1015

Uncertainties

362. Throughout this document, we have made assumptions about the cost and efficiency of various control measures. However, at these relatively low levels of dust or aerosol, control of air contaminants is an empirical process and the only truly reliable solution is to build and test prototypes. Clearly this is not possible, so all assumptions will be bedevilled with inaccuracies, and when respirable crystalline silica levels below 0.1 mg.m^{-3} are being considered, the uncertainties become even larger

363. We have assumed costs to industry based on our perceived options and to some extent, this is a prediction. However, differing considerations may sway the companies involved. In some cases, better housekeeping and extra cleaning of floors may produce an undetermined reduction in exposure. Because these options are extremely difficult to quantitate, we have only assumed their uptake in industries where improvement is likely.

364. Closure is always an option for large companies when limits are tightened. Costs should then be based on redundancy payments, and the loss of income for the operating company. Balanced against this is the potential benefit of saving possible losses. Closure with or without the transfer of the work overseas is an option for International companies. These decisions are dependent on the individual company's balance sheet at the time and therefore difficult or impossible to predict. The silica sand production industry may need large automated bagging units to comply with new limits and some companies with overseas production units can take advantage of lower labour costs.

365. The sectors will vary in their response to increased costs, and even accurate initial figures are often difficult to obtain. The construction industry is a continually changing scene and accurate numbers, even when possible, are short-lived. Many hand-held saws used for cutting silica-containing material (around 80%) are on short-term hire and the numbers change daily. In tunnelling, increased mechanisation could be increasing RCS exposure but we have no definite data. In construction as a whole, the inconsistency of health surveillance may mean that benefits of reducing the limit are being underestimated. The sector that included the uses of silica sand and flour is a large and varied sector composed predominantly of SMEs. Reliable data is scarce and accurate numbers are difficult to obtain. Consequently, large assumptions have been made to calculate bottom-line figures. Although the costs may have been overestimated, there is an equal chance that we have seriously underestimated potential costs. As these will bear down on SMEs in particular, the effects may be proportionately large.

366. The basis of the estimations of increased costs is the assumption that current RCS exposure patterns can be used as a surrogate for the number of companies likely to bear increased costs. Even if this were true, with all the uncertainties involved in assessing the current RCS exposure pattern when monitoring data is far from comprehensive, the final results are bound to be uncertain, even if cost estimates for new equipment and running costs were totally accurate. Taking the percentage of samples that exceeded a potential limit as being a guide to the percentage of sites that need control improvements is speculative but it is transparent; however the uncertainties involved are large. In the case of the quarry

industry, this assumption can lead to high-calculated costs because of the large number of sites and the exposure pattern being assumed from post-1997 HSE visit data which despite being the best guide available, may not always represent the current state of the industry. Another source of uncertainty is that HSE-generated exposure data for all substances has fallen dramatically in quantity since 1997.

367. The bottom line figures can therefore only be used as a rough guide. Of greater import are the descriptions of the industry sector and the individual factors that lead to RCS exposure. They lead to an understanding of the problems that the industry sectors are likely to face if the RCS exposure limit is progressively lowered.

8. CONSULTATION WITH SMALL BUSINESSES: THE SMALL FIRMS IMPACT TEST

368. As detailed in section 9(ii), we have contacted a range of small businesses by phone or by e-mail and we have visited more than fifteen sites where fewer than 50 workers are employed. The HSE questionnaire on the potential costs to comply with lower RCS exposure limits (Annex 5, Tables 10 to 37) produced additional comments from companies, many of whom were SMEs. The view most often expressed was that a new RCS limit set at 0.1 mg.m^{-3} would be achievable but that a limit set at 0.05 mg.m^{-3} or below would cause severe financial difficulties.

369. The Small Business Service (SBS) has been consulted and appreciates HSE's view that this proposal has the potential to affect a very large number of small businesses (SMEs) - across a wide range of sectors. If the exposure limit is set too low then businesses will struggle to comply. The Small Business Service has asked for it to be noted that firms spend a significant amount of time keeping up to date with revised and new regulations. The cost of this is likely to be proportionately higher for small firms than for large ones.

370. A disproportional impact on small businesses is expected to arise in the industrial minerals sector (where silica sand/flour is produced) and also, more particularly, in the sector where silica sand and flour is used (where the large majority of the companies involved are SMEs and where quantification of potential extra costs is most difficult to achieve).

371. According to a reply from an industrial mineral production trade association, an RCS limit set at 0.05 mg.m^{-3} will result in "major upgrades such as automatic bagging." Such fixed investments often disproportionately affect small firms.

372. Visits to small companies engaged in using silica sand/flour elicited concerns about the impact of any RCS limit below 0.1 mg.m^{-3} . There are a wide variety of uses of silica sand and flour, and the firms often have relatively small capital reserves. In the production and use of jewellery casting investment powder, there is the potential for export penetration if the small UK firms are unable to upgrade their facilities to comply with an RCS limit set at 0.1 mg.m^{-3} .

373. But the problems for small firms will not be confined to these sectors alone; Questionnaires returned from smaller companies in the foundry sector were often pessimistic; some smaller foundries suggested that a reduction in the RCS limit to

0.05 mg.m⁻³ would result in “remote operations”, “filtered fresh air”, “a new foundry” and in another case, “closure.”

374. Some smaller ceramics companies suggested that an RCS limit set at 0.05 mg.m⁻³ would mean “vast improvements to LEV” and “an upgrade to LEV – new installations”.

375. In the brick and heavy clay sector, similar sentiments were expressed. An RCS limit set at 0.05 mg.m⁻³ rather than at 0.1 mg.m⁻³ would mean “a new extraction system”, “the wearing of respirators for the whole day”, and in one case, was deemed “not practicable”.

376. On the basis of this assessment, HSE believes that an RCS exposure limit set at 0.1 mg.m⁻³ would not impose a substantially disproportionate burden on small businesses. However, a limit of 0.05 mg.m⁻³ would impose such a burden.

9. COMPETITION ASSESSMENT

377. This limit will affect many sectors and many markets. In such cases, the Office of Fair Trading (OFT) recommends that the markets chosen for investigation are those that are most likely to suffer most from adverse competition effects. Typically these markets are where there is the greatest concentration of suppliers; in this case, brick manufacture and the heavy clay industry and the quarrying of silica sand and flour have been identified as the major concerns.

Brick manufacture

378. The brick-making and the heavy clay industry covers a wide variety of clay brick and tile manufacturing, ranging from highly automated production of facing bricks with computerised kilns and processes to the traditional, labour-intensive hand making processes.

379. Bricks and tiles are traditional materials for construction and possible substitutes are limited. The industry undergoes technological change slowly and demand for bricks is dependent on activity in the UK housing market, which undergoes periodic peaks and troughs. However, importation of bricks from Europe is a factor when prices rise in the UK and/or when excess brick production occurs in Europe.

380. Currently, there are imports of bricks into South East England from Europe where the relatively small distances make importation of such heavy products financially worthwhile. In 2002, Customs and Excise estimated that 100 million bricks were imported into the UK but the industry estimated the figure to be 150 million (about 5% of the total market). Reasons for this importation include:

- (1) Flat demand in Europe has led to a stockpile of bricks and an ongoing need to move them out to keep their own factories busy.
- (2) In the early 1990s, the UK brick manufacturing industry underwent a rationalisation process and reduced output. Prices rose slightly but current output only just meets current demand.

- (3) Increased recent demand for new houses, especially in the South East helps to “suck in” imports if these can be supplied at a competitive price.

381. In the UK brick and heavy clay industry, there is a high degree of supply concentration. In these circumstances, there is the potential for adverse competition effects. A new RCS limit could affect British industry more than the European competition but the effects depend on where the limit is set. It is believed that a new RCS limit set at 0.1 mg.m^{-3} will only have a very minor effect the extra costs could increase the European imports. A new limit set at 0.05 mg.m^{-3} will be more significant in terms of competition and could result in closures of some UK brick works and an increased import penetration. There would be a need for extra monitoring and large capital costs at most sites, resulting in much larger start-up costs for any new enterprise.

382. A new limit set around 0.01 mg.m^{-3} would have massive implications for the UK industry and would result in many closures and a dependence on imported bricks for some parts of the UK.

383. Overall, the bricks and clay products would remain the same but production costs would increase dramatically if a new RCS limit was set below 0.1 mg.m^{-3} .

Quarrying of silica sand and flour

384. This sector is also one with a high supply concentration. About twelve UK companies produce about 4 million tonnes annually of silica sand at a number of sites. Some of the silica sand produced at the quarry is ground finely to produce silica flour by three companies. This flour has a number of specialist uses, and for many of these uses there would be no obvious substitute materials.

385. Silica sand can only be extracted where the mineral occurs and where extraction is economically feasible. This means that capital investment must be justified. There are thus few extraction sites, and replacing old or developing new process lines involves major investment decisions.

386. A reduction in the RCS limit to 0.1 mg.m^{-3} would have little effect on existing competition because the extra costs would be equally spread over the large companies, and importation of quarry material from Europe is unlikely. New entrants to the sector would not be adversely affected but would need to locate suitable sites.

387. As already outlined in the silica sand production section (5;a;i), a reduction in the RCS limit to 0.05 mg.m^{-3} could bring in significant extra costs owing to the need for full automation of the bagging areas and could result in the transfer of some production overseas. A reduction in the RCS limit to 0.01 mg.m^{-3} would almost certainly produce this result. A reduction in the RCS limit to 0.01 mg.m^{-3} would significantly increase running costs as well as capital costs, prevent any new entrants and could well close the current sites.

388. Overall, the competition filter suggests that a new RCS limit set at 0.1 mg.m^{-3} will produce few adverse competition effects in any of the industry sectors. However, a new RCS limit set at 0.05 mg.m^{-3} and especially one set at 0.01 mg.m^{-3} , would produce adverse competition effects.

10. ENFORCEMENT AND SANCTIONS

389. Enforcement of the new limit would occur routinely through HSE's inspection visits. Any enforcement action taken would be in accordance with the Enforcement Management Model (EMM), a robust framework that aids inspectors making enforcement decisions in line with the HSE Enforcement Policy Statement. Experience with previous RCS limits suggests that industry rates of compliance would be high for a limit that imposes manageable costs on industry.

390. The ultimate purpose of enforcing authorities is to ensure that duty holders manage and control risks effectively, thus preventing harm. The Health and Safety Commission's (HSC) Enforcement Policy Statement (which can be found at <http://www.hse.gov.uk/pubns/hsc15.pdf>) sets out the principles inspectors should apply when determining what enforcement action to take in response to breaches of health and safety legislation. The stated purpose of enforcement is to:

- ensure duty holders take action immediately to deal with serious risks to health and/or safety;
- promote and secure compliance with the law;
- ensure duty holders who breach health and safety requirements are held to account where appropriate, including punitive action where appropriate.

Fundamental to this is the principle that all enforcement action should be proportional to the health and safety risks and the seriousness of the breach.

391. A soundly based numerical limit, which indicates the minimum standard of performance, is a useful tool in managing health risks. An indication of how far limits are exceeded will inform inspectors as to the seriousness of the breach and the extent of the actual risk. WELs are useful in determining benchmarks for certain substances and if they are exceeded the risk gap may be substantial by definition and some form of enforcement action would be expected using the EMM

392. Alongside the setting of a new limit HSE will be publishing a range of COSHH Essential-style control guidance sheets on Silica (SILICA Essentials) during the Autumn 2005. The SILICA Essentials sheets will be freely available on HSE's website (www.coshh-essentials.org.uk). It is hoped that the use of these sheets will also help boost compliance rates. The guidance sheets will provide advice on good practice for about 50 industrial tasks and processes that generate exposure to dust containing respirable crystalline silica. During inspection visits HSE inspectors will look to see that there is compliance with good practice either based on the HSE control guidance sheets or on other sources of advice on good practice such as guidance from trade associations.

393. An inspection/enforcement initiative on Silica is planned for 2006/07 that will have an associated inspection protocol which will include initial enforcement expectation.

11. MONITORING AND REVIEW

394. The new WEL for RCS will be monitored and evaluated as part of HSE's Silica Action Plan. There are a number of elements to this plan. One refers to the development by HSE of SILICA Essentials as described above in paragraph 392. As part of the requirement of the new WEL system, workplace exposures must be controlled according to the principles of good practice. Therefore, the free provision of SILICA Essentials on HSE's website will facilitate compliance with the new WEL. A further requirement of the new WEL system is that exposures must not exceed the WEL. To ensure compliance with this requirement HSE plans a major Field Inspection Initiative to commence at the time of implementation of the new WEL. This Inspection Initiative is a major element of the Silica Action Plan. As part of this initiative, HSE inspectors will promote SILICA Essentials, and will also promote awareness, understanding and compliance with the new WEL, taking enforcement action where necessary. Field Inspectors will be issued with a Briefing Pack to ensure consistency of approach throughout the country. Over time, the feedback from this Inspection Initiative will allow HSE to monitor and review the effectiveness and impact of the new WEL. A further element of the Silica Action Plan will be a survey to monitor exposures to RCS in targeted industry sectors; these will include brick making, quarries, construction and stonemasonry. This survey will be independent of the inspection initiative and will also constitute a separate and objective form of monitoring and review.

12. CONSULTATION

(i) Within Government

395. Prior to publication, HSE will consult the Cabinet Office, Department of Trade and Industry, Department of Work and Pensions, Department for the Environment, Food and Rural Affairs and the Department of Health.

(ii) Public consultation

396. The following trade associations and unions were consulted:

Trade associations:

Association of Concrete Industrial Flooring Contractors (ACIFC), 33 Oxford Street, Leamington Spa CV32 4RA.

Association of Interior Specialists (AIS), Olton Bridge, 245 Warwick Rd., Solihull, West Midland B92 7AH.

British Ceramics Confederation, Federation House, Station Rd., Stoke-on-Trent ST4 2SA.

British Drilling Association (BDA), Wayside, London End, Upper Boddington, Daventry NN11 6DP.

Castings Technology International (CTI)

Contract Flooring Association (CFA), 4 St. Mary's Place, The Lace Market, Nottingham NG1 4PH.

Craft Potters Association of Great Britain, 7 Marshall St., London WV1 1LP.

Drilling and Sawing Association (DSA), PO Box 16, Belper, Derbyshire DE56 4WF.

The European Association of Industrial Silica Producers (EUROSIL), Bd. S. Dupois, 233 Box 124, B-1070 Brussels, Belgium.

Federation of Building Specialist Contractors (FBSC), Kinsham Consultancy Ltd, Unit 9, Lakeside Industrial Estate, Stanton Harcourt, Oxford OX29 5SL

Federation of Plastering & Drywall Contractors (FPDC) Construction House, 56 – 64 Leonard Street, London EC2A 4JX.

National Association of Memorial Masons (NAMM,) 27a Albert Street, Rugby, Warwickshire.

National Fireplace Association (NFA), 6th Floor, The McLaren Building, 35 Dale End, Birmingham B4 7LN.

National Specialist Contractors Council (NSCC), Carthusian Court, 12 Carthusian Street, London EC1M 6EZ.

Quarry Products Association, 156 Buckingham Palace Rd, London SW1W 9TR.

Silica and Moulding Sands Association, 18 South Acre Drive, Macclesfield, Cheshire SK11 7EW.

Stone Federation of Great Britain (SFGB) Channel Business Centre, Ingles Manor, Castle Hill Avenue, Folkestone, Kent.

The Tile Association (TTA), Forum Court, 83 Copers Rd., Beckenham, Kent BR3 1NR.

Trade Unions:

Owen Tudor, Trade Unions Congress, e-mail: Otudor@TUC.ORG.UK.

In addition, over 20 UK companies were visited and consulted about this RIA.

397. As well as the trade associations listed above and the individual companies visited, a range of HSE publications and publications from peer-reviewed literature were consulted for relevant information.

13. SUMMARY AND RECOMMENDATIONS

398. The retention of the current MEL (0.3 mg.m^{-3} as an 8-hour TWA) is not possible for a variety of reasons outlined in the section headed "options".

399. The setting of a new and lower limit for respirable crystalline silica will impose a series of extra costs on UK industry. A limit set at 0.01 mg.m^{-3} is of theoretical

interest only because it would dramatically affect many well-known and established industry sectors and could well impinge on several more sectors where silica is not currently discernable from background concentrations. If the limit is set at a very low level (at 0.05 mg.m^{-3} or below) there is the potential for the closure of parts of some industry sectors. The quarrying industry, for example, is based in predominantly rural sites where alternative employment may be difficult to find. Some brick manufacturing sites, especially those employing Hoffman kilns or having large areas of old plant, may well follow suit. This level would also create special difficulties for many small businesses, which use silica sand and flour for a wide range of products.

400. A limit of 0.1 mg.m^{-3} (8-hour TWA) for RCS, set as a WEL, should impose extra costs without causing major redundancies. The largest costs could well occur in the quarry industry – a consequence of the processes, the large number of sites and the large capital costs that would be required to make significant reductions in RCS exposure. Overall, a limit of 0.1 mg.m^{-3} (8-hour TWA) is a limit that in the opinion of HSE, is reasonably achievable across the broad spectrum of industry sectors where exposure to silica occurs. In terms of occupational health protection, it would represent an improvement compared to the current limit of 0.3 mg.m^{-3} and the associated industry costs would not be grossly disproportionate. It is an airborne level that is possible to measure with sufficient accuracy and precision for enforcement purposes, whereas a limit set at a lower level could be problematic in this respect. This therefore is the level at which HSE believes UK industry could comply (with costs) and where compliance could bring a significant health benefit.

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ANNEX 1 - RCS EXPOSURE DATA

The data on RCS exposure in all industry sectors was obtained from a variety of sources.

- (1) *EH 74 data.* The HSE booklet – “Respirable Crystalline Silica – Exposure Assessment Update, EH74/2” was published in 1998 and contained a review of silica exposures up to that date. Additional data was added from between 1994 and 1995 with a little extra data from 1996 and 1997. All of this data is summarised under the heading “EH74 data”.
- (2) *NEDB data.* HSE’s National Exposure Database (NEDB) contained data from the last twenty years but much of the early data was included in the EH74/2 review. Only post-1997 NEDB data is included under the heading “NEDB data”.
- (3) *Industry data.* During our discussions with industry we received some relatively new exposure data (post-2000) and it is included in this document.
- (4) *Published data.* Relevant data published after 1997 in peer-reviewed journals were also included in cases where the other sources of data were few.

Table 1. A summary of personal respirable crystalline silica exposures (task-based) from the HSE Occupational Hygiene Visit Report (OHVR) database from 1992 to 1997 as published in the HSE booklet – “Respirable Crystalline Silica – Exposure Assessment Update, EH74/2”

Sector	Number of sites	Number of samples	Percentage of values above 0.2 mg.m ⁻³	Percentage of values above 0.1 mg.m ⁻³	Percentage of values above 0.05 mg.m ⁻³
Foundries	8	56	6	18	29
Ceramics	9	56	12	43	88
Brick/heavy clay	5	28	14	64	82
Overall	22	140	11	37	63

Table 2. Personal RCS exposures (task-based) in construction from Chisholm (1997) – published in EH74/2. Data from 1996 -1997.

Task	Number of samples	Maximum value mg.m ⁻³	Percentage of values above 0.3 mg.m ⁻³	Percentage of values above 0.1 mg.m ⁻³	Percentage of values below 0.1 mg.m ⁻³
Tunnelling	11	0.45	18	27	73
General work	46	94	30	65	35

Table 3. Personal RCS exposures (task-based) from HSE's NEDB (post-1997)

Sector	Number of sites	Number of samples	Percentage of values above 0.3 mg.m ⁻³	Percentage of values above 0.1 mg.m ⁻³	Percentage of value above 0.05 mg.m ⁻³	Percentage of value above 0.02 mg.m ⁻³
Foundries	2	17	12	12	24	41
Ceramics	7	79	9	24	53	87
Quarries	3	19	0	11	58	84
Miscellaneous	2	10	10	10	40	40
Overall	14	125	8	19	49	77

Table 4. RCS exposure (8-hour TWAs) at small potteries – data from HSE survey during 1997.

Task	Number of samples	Range	Percentage of values above 0.3 mg.m ⁻³	Percentage of values above 0.07 mg.m ⁻³	Upper quartile (mg.m ⁻³)
Casting	16	0.04 – 0.17	0	50	0.11
Fettling/sponging	19	0.02 – 0.31	0	42	0.19
Dipping	7	0.01 – 0.07	0	0	0.06
Miscellaneous	23	0.01 – 0.2	0	13	0.07
Overall	65	0.01 – 0.31	3	34	0.1

Table 5. RCS exposure at large potteries (8-hour TWAs). Data from HSE survey during 1997.

Task	Number of samples	Range (mg.m ⁻³)	Percentage of values above 0.3 mg.m ⁻³	Percentage of values above 0.07 mg.m ⁻³	Upper quartile (mg.m ⁻³)
Casting	28	0.003 – 0.24	0	3.6	0.04
Fettling/sponging	47	0.006 – 0.13	0	6.4	0.04
Cleaning	5	0.02 – 0.053	0	0	0.05
Miscellaneous	9	0.002 – 0.04	0	0	0.02
Overall	89	0.002 – 0.24	0	4.5	0.04

Table 6. Personal RCS exposures in quarries (8-hour TWAs) from industry data (1999 – 2003. Despite a wide variation in rock types and tasks sampled, the proportion of samples above 0.01 and 0.05 mg.m⁻³ remained around 40% and 20% respectively.

Year	Number of sites	Number of samples	Percentage above 0.1 mg.m ⁻³	Percentage above 0.05 mg.m ⁻³	Percentage above 0.01 mg.m ⁻³
1999	17	69	6	14	41
2000	27	100	14	25	41
2001	24	107	12	17	35
2002	22	85	25	28	42
2003	6	24	4	13	38

Table 7. Personal RCS exposures during silica flour production (8 –hour TWAs) from industry data 2001 – 2003. One large quarry company producing silica flour supplied the data. RPE is worn during bagging and it is this process that produces the high exposures.

Year	Number of samples	Percentage above 0.3 mg.m ⁻³	Percentage above 0.1 mg.m ⁻³	Percentage above 0.05 mg.m ⁻³	Percentage above 0.02 mg.m ⁻³
2001	3	100	100	100	100
2002	6	0	100	100	100
2003	6	16	50	67	100

Table 8. Personal RCS exposures in brick making (8-hour TWAs). Data supplied by industry for period 2002 - 2003

Number of sites	Number of samples	Percentage above 0.3 mg.m ⁻³	Percentage above 0.1 mg.m ⁻³	Percentage above 0.05 mg.m ⁻³	Percentage above 0.02 mg.m ⁻³
3	33	3	24	48	76

Table 9. RCS exposure in stonemasonry categorised under rock type – from HSE’s Respirable Crystalline Silica Exposure Assessment Document (EH74/2, 1999)

Rock type	Number of samples	Percentage above 0.4 mg.m³	Percentage above 0.2 mg.m³	Percentage above 0.1 mg.m³
Marble/ limestone	34	9	9	15
Granite	42	0	11	22
Sandstone/yorkstone	12	75	75	83

ANNEX 2 - SILICA ESSENTIALS

This section contains information on Silica essentials and details of the relevant sheets for each industry.

COSHH Essentials gives advice on the controls based on the potential for harm (Risk Phrase) and the potential for exposure. In 2003, the scheme was extended to deal with certain asthmagens and process emissions, including some scenarios for the control of silica. Work is in progress to add other industry sector advice on the control of exposure to silica for publication in late 2004. The draft titles and control approaches are set out in the tables below for each industry. They all outline the hazard and cover access, design and equipment, maintenance, examination and test, cleaning and housekeeping, personal protective equipment, training and supervision, and an employee checklist. They are listed below by industry.

Foundry industry

Table 1: Foundry industry – silica sheets

Sheet No.	Date	Topic	Control approach
FD04	2003	Sand plant	LEV
FD05	2003	Coremaking (sand moulds)	LEV
FD06	2003	Knock-out and shake-out	RPE and LEV
FD07	2003	Fettling (smaller castings)	LEV
FD08	2003	Fettling (larger castings)	RPE and LEV
FD09	2003	Shotblasting - cabinet	Containment
FD10	2003	Thermal cutting and gouging	RPE and LEV
FD13	2003	Cleaning dust collectors	RPE.
FD15	2004/5	Furnace and kiln relining	RPE.

The requirements for maintenance, examination and test differ.

FD04, FD05, FD06 Once every 14 months

FD07, FD08 Once every 6 months

FD09 Once every month

FD10 Once every 14 months (ferrous) or 6 months (non-ferrous)

Ceramics

Table 2: Ceramics industry – silica sheets

Sheet No.	Date	Topic	Control approach
CT02	2004/5	Glaze preparation	RPE and LEV
CT03	2004/5	Casting	General ventilation
CT04	2004/5	Fettling flatware, tiles	LEV
CT05	2004/5	Fettling hollow, sanitary ware	LEV
CT06	2004/5	Kiln placing, unloading	General ventilation
CT07	2004/5	Tile pressing	LEV
CT08	2004/5	Spraying frits, glazes	LEV

Brick manufacture and heavy clay**Table 3: Brick-making (heavy clay) industry – silica sheets**

Sheet No.	Date	Topic	Control approach
BK02	2004/5	Clay milling	General ventilation
BK03	2004/5	Sand handling, screening	LEV
BK04	2004/5	Brick facing with sand	LEV
BK05	2004/5	Drying, firing and kiln unloading	LEV-R.
BK06	2004/5	Dehacking and batching	LEV (L.A.D.)

Clay milling can be done without the need for close personal supervision and closed circuit TV (CCTV) monitoring is suitable for reducing exposure.

LEV-R. – Refuge or cab supplied with clean air. Kiln work using vehicles requires a ventilated cab. RPE obscures sight lines.

Dehacking and batching – LEV uses a Local Air Displacement (L.A.D.) technique.

Quarry industryAggregates, surfacing materials**Table 4: Quarry industry – silica sheets**

Sheet No.	Date	Topic	Control approach
QU02	2004/5	Rock drilling	LEV+W.
QU03	2004/5	Digging, ripping	LEV-R.
QU04	2004/5	Crushers, conveyor transfer	LEV-R +W.
QU05	2004/5	Screening	Containment + W.
QU06	2004/5	Milling	Containment + R.

QU07	2004/5	Sand, aggregate drying	LEV
QU08	2004/5	Packing for supply	RPE and LEV
QU09	2004/5	Bag-house, scrubber cleaning	RPE.
QU10	2004/5	Reconstituted stone making	To be determined

LEV+W. – Dust extraction and water suppression

LEV-R. – Refuge or cab supplied with clean air

Crushing, screening and drying can be done without the need for close personal supervision and closed circuit TV (CCTV) monitoring is suitable for reducing exposure.

Slate quarries

Table 5: Slate making – silica sheets

Sheet No.	Date	Topic	Control approach
SL02	2004/5	Primary sawing	W.
SL03	2004/5	Automated secondary sawing	LEV
SL04	2004/5	Sawing special sizes, shapes	LEV
SL05	2004/5	Manual splitting	LEV (L.A.D.)
SL06	2004/5	Dressing, edge bevelling	RPE + LEV
SL07	2004/5	Packing	LEV (L.A.D.)

Splitting, packing – LEV uses a Local Air Displacement (L.A.D.) technique.

Industrial Minerals

Silica sand production

Silica sand quarrying

Silica sand quarrying

Table 6: Silica flour use – Silica Essentials

Sheet No.	Date	Topic	Control approach
SX01	2004/5	Bag transfer, weighing	RPE + LEV
SX02	2004/5	Mineral dusts - weighing	RPE + LEV
SX03	2004/5	Dry mixing	RPE + LEV
SX04	2004/5	Small packing operations	RPE + LEV

Construction industry

Table 7: Construction industry – silica sheets

Sheet No.	Date	Topic	Control approach
CN02	2004/5	Concrete scabbling	RPE and LEV+W
CN03	2004/5	Chasing (hand-held power tools)	RPE +W
CN04	2004/5	Drilling, coring (hand-held)	RPE and LEV+W
CN05	2004/5	Crushing, screening	W
CN06	2004/5	Clearing demolition rubble	LEV-R+ W <u>or</u> RPE
CN07	2004/5	Cutting (hand held cutter)	RPE +W
CN08	2004/5	Abrasive blasting	RPE + W
CN09	2004/5	Tunnelling, shaft-sinking	T*
CN10	2004/5	Pneumatic breaker (indoors)	RPE + Air
CN11	2004/5	Cutting filled composites	RPE

LEV+W. – Dust extraction and water suppression

RPE + W. – RPE with water suppression

W. – water suppression

LEV-R. – Refuge or cab supplied with clean air

T* - water suppression, refuge in larger tunnels and RPE in smaller tunnels. Also use dilution ventilation.

RPE+ Air – Fresh air blown to work area

Stonemasonry industry

Table 8: Stonemasonry industry – silica sheets

Sheet No.	Date	Topic	Control approach
ST02	2004/5	Primary, secondary sawing	W.
ST03	2004/5	Boring, polishing (static)	W.
ST04	2004/5	Cutting, polishing (hand-held)	RPE and LEV (L.A.D.)
ST05	2004/5	Chiselling (manual, pneumatic)	RPE + LEV (LAD)

W = water suppression

Cutting, polishing – LEV uses a Local Air Displacement (L.A.D.) technique.

Sawing, boring and polishing can be done without the need for close personal supervision, and closed circuit TV (CCTV) monitoring is suitable for reducing exposure.

ANNEX 3 – PROCESSES WHICH RESULT IN EXPOSURE TO SILICA IN THE INDUSTRIES AFFECTED

This Annex contains details of the processes which could result in exposure to RCS in the industries listed in business sectors affected (see page 12). This information, along with the exposure data in Annex 1 was used to calculate the compliance costs in the business sectors affected section (para 100 - 360).

Foundry Industry

Overview of relevant processes:-

Moulds for the molten metal are produced from mixing sands and additives, and either adding to formers (made of wood, metal or plastic) by hand or by machine. Sand recovery and sand mixing plants can be areas of potentially high RCS exposure, and sand storage/loading/unloading may produce significant RCS exposure if the sand is ground down heavily by vehicular traffic. Automated moulding machines at a capital cost of up to £1 million will reduce exposure significantly during moulding but retrospective fitting to current machines is difficult, and the need for long runs makes it unsuitable for “jobbing” foundries therefore it is a limited option. Suitable RPE programmes may be needed instead. Keeping the mould sand moist (3% water content) will help to reduce RCS exposure and often resins are used.

Cores are made in a similar way. Some dry coat cores use powder for better finishes and though these procedures may be very dusty, they are fortunately rare.

The mould may be heat-cured and molten metal is poured in to make a cast. After cooling, removal of the mould sand is achieved by vibration and/or knockout. The industry standard for knockout is a rear draught hood angled over the track or knockout deck. Down-draught decks are less effective and cause problems with sand recovery.

Shotblasting, fettling and polishing of the raw casting are done to finish the metal product. Shot-blasting to remove sand residues should be carried out prior to fettling, if at all possible.

RPE is essential when fettling inside large hollow castings (e.g. ingot moulds, tank turrets, marine diesel engine casings), but fettling of large castings (especially if internal fettling is required) is difficult to control by engineering controls/RPE because of the need for access and the possible high temperatures. For certain castings, it may not be possible to fettle entirely within the booth and even when fettling inside the booth, high concentrations of respirable crystalline silica are likely due to dust jets and air turbulence. However, the foundry industry believes that well-designed and suitable LEV can cope with all but the largest castings without the need for RPE.

For small and medium castings, booths or bench areas can control exposures but RPE may still be needed for the larger castings in this category because dust may be made airborne. Larger floor castings must rely on general extraction or ventilation. Roof fans or roof extraction may bring fine dust into breathing zone and down draughts are common. Regular floor cleaning may be needed to prevent the spilled sand being ground down to a respirable size, but sand floors are not

recommended by industry advisors. If sand is needed to absorb hot metal splashes, the sand should be restricted to small pits.

In some potentially RCS-producing processes (dust from fettling large and medium-sized castings, dust and from thermal cutting and gouging, dust from knock-out, shakeout and attrition, dust from cleaning dust collectors) engineering controls may struggle to reduce exposure below 0.1 mg.m^{-3} , and here RPE will be the critical control. Engineering controls are there to mitigate the risk for the worker and other people, a fact endorsed by the ACTS working group on COSHH Essentials recently (ACTS, 2003). Again, the foundry industry believes that LEV can cope as long as it is both well designed and suitable for the purpose. One way to reduce exposures substantially in some of these processes is by robotics – with high capital expenditure.

Maintenance procedures such as bag filter changing, and kiln wrecking are likely to produce high exposures but the sporadic nature of the work means that permits to work and suitable RPE should help to control them. RPE for silica will generally not be needed when cleaning wet scrubbers unless they have been allowed to completely dry out. RPE will generally be needed when cleaning a filter unit or changing the bags. Portable LEV may be possible and should be used if it is.

Ceramics

Overview of relevant processes:-

The sector can be divided into three sections:-

- (a) Mainstream, large volume producers
- (b) Small-volume versions of (a)
- (c) Craft potters – producing one-offs and “art”.

The two basic clays used are primary clay (like china clay) and sedimentary or secondary clay like the ball clays. In art and craft potteries, clay body (20 –50% crystalline silica) is bought in ready prepared form and used direct from the bag for hand modelling and potter’s wheel throwing.

In the main potteries, the clays are mixed with water to produce the required composition and after removal of impurities, the “slip” will follow one of three routes:

- (i) Plastic clay manufacture. Slip is filter-pressed to squeeze out water and produce semi-plastic cakes. A pug mill mixes the clay and removes air, and the clay is formed by machines that apply a static or revolving tool to the clay and force it to shape. When partially dried, it can be released and handled.
- (ii) Tile manufacture and industrial products. “Slip” is passed through a spray drier and the granulate is pressed.
- (iii) Slip casting. More intricate pieces are cast using “casting slip”, made by mixing plastic clay, water and deflocculants in a ‘blunger’, to form a low-density clay suspension. This is usually added to a porous plaster-of-paris

mould and left briefly for a surface deposit to form. By inversion of the moulds, excess slip is emptied into a reservoir. Slip drops may dry out and accumulate. After draining, the mould is trimmed to remove excess clay and allowed to dry fully. The moulding is then removed and dried further.

Once formed, the pieces must be fettled (wet or dry). Dry fettling should be carried out at an extracted booth. Smoothing (towing) is accomplished with fabric or a wet sponge and drying may be accelerated by heating before either firing in a kiln, or sent for glazing without firing. The first firing is the "biscuit firing" which varies depending on the type of ware (pottery) being made.

Silica flour is often used in glazes and is a potential source of RCS exposure. Although many companies buy in glaze, where it is made up on site there must be an extracted booth and RPE.

The main factor affecting RCS exposure in the ceramics industry is spillage. Although primary exposure occurs during the production process, clay slip and off-cuts or scraps of plastic clay can dry out and, if not promptly cleared up, will be ground down by pedestrian and vehicular traffic and dispersed to produce secondary RCS exposure. The production of sanitary ware in particular uses large quantities of clay so cleanliness is especially important here.

Brick manufacture and heavy clay

Overview of relevant processes:-

Clay is usually quarried on site and often stockpiled before use. This may entail clay being excavated from the quarry by bucket and drag-line and sent on long conveyors to the stockpile – processes similar to quarrying although dust levels are usually lower because the clay is damper and only conveyor maintenance staff are usually exposed. Although clay preparation areas are large, staffing levels tend to be low. Whereas the quarry industry has relied more on the segregation of the worker, methods of control in brick manufacturing consist of enclosing and extracting all the grinding plant, conveyors and transfer points. This can be expensive and spillages/fugitive emissions are difficult to prevent. Thus cleaning and general housekeeping is important. Vacuum cleaning should be routine but at some sites, brush sweeping still occurs with formal housekeeping taking place at shutdown/breakdown. Regular and efficient cleaning is important for all brickworks and vacuum cleaning is the preferred option. Multipoint, high-efficiency vacuum cleaning systems at a cost of around £500,000 per site may be necessary to adequately control spillages and settled dust.

The clay is crushed and ground (either wet or dry) to a fine consistency before being mixed and then either extruded or moulded into bricks. Dry pan mills are inherently very dusty. But in the clay preparation area respirable dust levels are less dependent on weather conditions because dust is also produced by vehicle movement. If pan mills are used, they rotate and mould damp clay, but with stone rollers at medium or high speed, new surfaces are created and dry dust can be thrown out. Full-time attendance at this process is unnecessary and CCTV monitoring is possible. The use of atomised water suppression has been trialed at certain points in the processes. The water mist can act as a blanket to suppress the clay dust, but on-

going fine-tuning of the atomiser is needed to provide control of dust without the production of sludge.

There are three main production processes for making bricks:-

(1) Soft mud moulding by hand or by machine - If made by hand, the clot (containing more than 20% water) is coated with sand and added to a mould that has been pre-coated with sand. For machine-moulding, the bricks are produced by mixing clay with additives such as colourants and sand (for body), the particle size is reduced to below 1mm, and water is added to produce a sloppy mix. This mix is forced through steel dies by spiral blades into sanded moulds and no two bricks are identical. The moulds are washed with water, dried and sand is added again in preparation for the next clay addition.

(2) Extrusion/wire cutting – This represents about 40% of the total UK production. Plastic clay is driven through a die with to form a continuous column (containing 15 – 20% water). Perforations are formed by core bars in the die-head. Surface texturing is carried out immediately and colours may be added. The column is cut into bricks by a multiple wire cutter, the bricks are palletised onto a drier car for entry to a tunnel drier. After drying for 36 hours at 100°C, the bricks are loaded onto kiln cars and fired in a kiln.

Extrusion and cutting is amenable to interfacing with automatic stacking and thus lower staffing levels.

(3) Semi-dry process – Used for Fletton bricks where the clay has a natural water content of 17 to 20%. A fine granular material is produced from the clay by grinding and pressing without reducing the natural moisture. A mechanical press compacts the material and a “frog” is imprinted in the surface which assists drying /firing.

Stiff plastic pressing is an unusual process and is a combination of extrusion which forms a brick-shaped clot and the clot is pressed in a mould to form the brick.

The general surfacing, setting, drying, firing and deacking procedures are summarised below.

Surfacing

Surfacing of the damp clay bricks with a coating made up of sand and other materials like oxides and colourants is usually applied by air-blasting. This impregnates the soft clay surface but has the potential for high silica exposures. Sand is used as a coating on bricks both as a parting medium and to convey decorative finishes and dyes. In automated brick production, this process can be enclosed and extracted. When hand-made bricks are produced, the coating is applied by rolling and placing bricks into dyed sand, making control much more difficult, but the mechanical nature of this process means that potential exposures are lower.

Water suppression of the surfacing dust has been trialed using underground conveyors to remove the fine dust but it was found that the resultant wet slurry was

difficult to remove. Efficient extraction for air-blast sanders can cost up to £250,000 at 2003 prices, with around 10% of this sum for annual running costs.

Setting

Setting prepares the bricks for the drying and firing stages. Automated setting machines are available at a cost of £2 million upwards and can replace 6 to 8 employees needed to fill the kiln cars. Packs are built by robot (block setting) - one operator can oversee the robot and one operator usually manually discards non-standard bricks.

These operations are the most labour intensive and difficult to control because dust is generated every time bricks are moved or knocked against each other when they are moved and stacked. Bricks with frogs are the worst culprits in this respect because the frogs collect dust.

Automation is possible but expensive. The number of employees exposed will fall but the bricks will still knock against each other (albeit at a faster rate) and dust will be released into the surrounding air.

Drying

The Fletton process does not require a drying stage. Otherwise, the kiln cars are stacked to allow optimal airflow and dried at low temperatures.

Firing

Three types of kilns are used in brick making – tunnel kilns, gas-fired intermittent kilns and Hoffmann kilns. Tunnel kilns are the modern option and the operator doesn't need to enter the kiln area because special carts are used for the bricks. Exposure is thus much lower.

Gas-fired intermittent kilns require more manual handling of the bricks and dust movement will increase potential RCS exposure.

It is believed that about five companies still use Hoffmann kilns. Bricks have to be individually set and removed - a labour-intensive process.

Clamp-firing is still used at some sites for premium product bricks. There are only four sites left using this traditional firing system and they produce bricks used for top-specification housing and there is a wide and natural variation in the colouring because of the firing method. The bricks are set in the clamp, which often sits on a floor composed of hardcore topped with crushed brick above a surface of loose sand. Bricks are stacked by hand and covered with a single layer of refractory brick. The clamp roof may be composed of materials such as asbestos cement. Adequate damping down of clamp floors and roadways was essential to help control RCS exposure in these sites because of the problems inherent in installing engineering controls in clamps. Power assisted RPE would be needed to reduce RCS exposure to 0.05 mg.m^{-3} or below.

After firing, the “dehacking” is done by hand and dust is always dislodged during this process. Coating with non-silica surface dressings has not been seriously investigated by the industry so the options are limited.

Dehacking

This also tends to be a labour intensive task carried out over a large area with the consequential problems for controlling RCS exposure. Whole packs of bricks may be lifted and separated, and sand spillage from the coating or frogs is the source of the silica exposure

After several days in the kiln, the dehacking is bound to be a dusty process and employees can be working nine hours a day, reliant on RPE to reduce exposure. Filtered air cabs can be fitted to forklift trucks in these kilns but this reduces visibility owing to dust deposition on cab windows. HSE ergonomists recommend the use filtered air cabs rather than RPE. The fitting of gas-firing (rather than coal-firing) kilns could reduce general dust exposure but some of the silica dust may be released with the gases produced from the ignition of internal oils in the clay. Exposure monitoring takes place annually at the sites in the summer months and exposure data suggests that although total dust levels are high, the respirable silica content is usually relatively low. For manual batching operations, down draught local air displacement (LAD) is the best engineering control measure.

Tile manufacture

Tile manufacture is a similar process to brick manufacture. The marls used for tile production will contain around 50% silica and contains about 10% water but after storage and grinding and rolling to reduce the particle size below 1mm, water is added to “sour” the mixture. The clay is extruded, the edges are trimmed and oil is dribbled onto the surface.

Sand is blown onto the surface of the moist tiles but the exposure problem arises from the excess sand. Too weak an airflow above the production line allows escape of dust, too strong a suction rapidly blocks filters. Sand that falls below the production line is captured on a conveyor belt and reused.

After drying (36 hours) the tiles are set for firing. As in brick manufacture, setting is a potentially dusty operation, but in some tile manufacturing sites, this process is fully enclosed.

Dehacking may be automatic but sorting (where the tiles are checked for soundness) could cause silica exposure. However, it appears that the dust from this process is relatively heavy and settles quickly. Hand-sorting needs to be performed without clashing the tiles together to reduce dust and silica exposure, but even with extraction above the line, respirable crystalline silica exposure can exceed 0.1 mg.m^3 . Because of the relatively large areas, the options for significantly reducing silica exposure are limited to robotics or mechanical handling.

In the case of hand-made tiles, the process is similar but after extrusion, the clays are placed into moulds lined with sand – and the surfaces are not sand-blasted.

Quarry Industry

This section considers only aggregates, materials such as surfacing materials and slate because these are considered to be large quantity, low-added value materials with minimal processing. Other materials such as silica flour differ in many respects and are therefore considered in section (5).

(a) Aggregates, surfacing materials

Overview of relevant processes:-

There are several stages in the production of these quarry products - drilling, blasting, loading, crushing, screening, coating and bunkering. Some areas such as secondary and tertiary crushers, screens and coating plants are amenable to enclosure and extraction. However, other areas such as drilling, loading and lorry tipping do not take place at fixed locations and are more difficult to control. Here, the options include wet suppression and refuges.

HSE's Quarries sector organised a survey during 1997 and discovered that although many controls have been installed, their use was not always optimal. Many of the dust problems were due to house keeping and recirculation of accumulated dusts in controlled environments like vehicles and static cabins. Vacuuming cleaning systems, rather than brushes, and the correct filtration systems are essential.

Dust clouds generated by rock drilling are dense but localised unless air movement is rapid. Drill operators have to work close to the drill bit to make any adjustments. The engineering options for control include LEV, wetting or segregation of the operator in a ventilated cab. EH74/2 (1999) suggests that these controls have only a limited success where high-silica rock is worked continuously, and that to reduce exposure sufficiently, RPE must be worn as well.

Since 1997, to comply with Environmental Protection Act authorisation requirements, all drills have to be provided with dust suppression. LEV is fitted on drill rigs as axial extraction but silica dust can escape from poor seals between the equipment and uneven ground. For horizontal drilling, a water spray can be added instead to reduce exposure.

Air-conditioned, ventilated cabs are becoming routine for large rigs, and remote drilling may be an option. This should reduce exposure to below 0.1 mg.m^{-3} but tends to be expensive at around £250,000 per unit. Drillers (about 1400 employees) currently represent about 4% of the total quarry workforce

Crushing plant operators were formerly one of the highest exposed groups but since 1991 they have been a priority for action. Enclosure and extraction are the controls of choice where possible but there are difficulties with parts of the plant such as the feed to the primary crusher and water suppression may be needed. The large areas involved do increase costs considerably and industry sources have suggested that to engineer out a single spillage point can cost more than £50,000. In cases like this, suitably located cabins equipped with video surveillance enable operators to have a safe refuge for observation where they would only need to leave the cabin to adjust

plant, remove blockages or deal with spillages (wearing RPE). The refuges should be ventilated with filtered fresh air from outside the building.

EH74/2 suggests that good management and regular cleaning could reduce respirable crystalline silica exposure to the staff to below 0.05 mg.m^{-3} . However, the time spent outside the cabin can produce a significant part of the exposure unless control is good. Reducing this sort of RCS exposure could be achieved by the fitting of hydraulic pickers or breakers to break up blockages at the feeds and by the fitting of automatic operations with video surveillance to the load-out chutes.

Upgrading of existing control rooms can be cheaper but to construct a new refuge from scratch (necessary for many older quarries) could cost £30,000 with annual running costs of £3,000 for extra power, filter replacement and regular cleaning of the room.

The vehicle drivers may be categorised into face loaders, dump truck drivers and stockpilers. Much of the RCS exposure results from dust generated by movement on site. It is already standard practice to use bowsers or fixed water sprays to dampen down dust, but exposure also occurs from operations where the rock is loaded into or out of lorries and this can be reduced by fitting air conditioning units to the vehicle cab. This is fully effective only where the cab is well sealed and the driver remains inside during loading operations. This will necessitate an increase in plant video surveillance to compensate for the reduction in visibility during loading. If this is combined with a system of regular cleaning for the inside of the cab, then exposures could be reduced below 0.05 mg.m^{-3} . Drivers currently constitute about 33% of the workforce – about 12,000 employees.

Slate quarries

Overview of relevant processes:-

Traditional slate working involves quarrying the slate and passing blocks into a workshop to be sawn into shape, where the operator splits the slates and piles them up until there are enough for dressing. Even with LEV, it is difficult to reduce RCS exposure below 0.1 mg.m^{-3} unless local air displacement (LAD) is also used.

Slate is used for floors, roofs, worktops and cladding, and is extracted by drilling along fault lines and sawing with diamond studded wire. Explosives may be used to break off large chunks. Drilling has the potential for high acute RCS exposure but any averaged exposure is reduced because drilling is usually performed for only short periods in each shift.

The large chunks of slate are moved to primary saw sheds where they are sawn to large square blocks of about two feet square whenever possible. The diamond-tipped circular saws have the benefit of water suppression, which also serves to reduce RCS exposure. The square blocks are then split in the sheds as a wet cube, hydraulic splitting machines push chisels into the block and split into thinner blocks (of a potential 4-slate thickness) ready for hand splitting.

Hand-splitting takes place, using a hammer and chisel, on a bench near to extraction grills, and produces 4 “rivings” of between 5mm and 9mm thickness.

Stacking of the rivings may create potential RCS exposure due to the dusty air currents that can be produced.

There are three ways to dress the rivings. A primary mangle dresses the rivings by chopping the edges into a final form. In some cases, the slate must be fed into a rotary dressing machine, which acts like a cylinder lawn mower, to tidy the edges by chopping a neat bevelled edge onto the slate. The final stage (if needed) is manual trimming by a machete-like blade. Some companies are experimenting with an automated dressing machine to reduce the manual handling (and potential RCS exposure) during dressing. However, this results in an operator spending more time per shift splitting the slates. Most sites also have an area for wet polishing of the slates and even here, RCS exposure can be significant.

The quarrying of the slate is similar to general quarrying and any extra costs for this portion of the process will have been included under the quarry sector. The higher RCS exposures occur during the working of the slate blocks and these are considered below.

The task of slate splitting tends to produce RCS exposures around 1 mg.m^{-3} but good LEV will reduce exposures to below the current MEL (0.3 mg.m^{-3}). Data obtained from the industry questionnaire supports this assumption with all thirty five slate splitters surveyed reporting RCS exposure between 0.1 and 0.3 mg.m^{-3} (Table 10, Annex 5).

Although the main sources of RCS exposure are slate splitting and the associated handling, another source of personal exposure to RCS is from contaminated clothing. Modern fabrics are essential to minimise this source.

Options for further reducing exposure are limited unless the splitting and stacking is contained within a booth – an extremely costly alternative. However a combination of LEV and local air displacement (LAD) if using low velocity, wide air displacement jets, is likely to be effective because the operator works in a very localised area. LAD has shown that RCS exposures consistently below 0.1 mg.m^{-3} are feasible.

Industrial minerals

These are lower quantity, high added value processed materials. The section is split into four to reflect the different sectors of silica sand production, silica flour production, specialist industrial mineral production (such as potash, gypsum and limestone) and the usage of industrial mineral products.

(a) Silica sand production

(a)(i) Silica sand quarrying

Overview of relevant processes

The processes used to extract silica sand from quarries vary depending upon the nature of the deposit in the ground. In unconsolidated (wind-blown) sand deposits, extraction involves the use of front-end loaders or excavators. The mineral is then transferred to the processing plant using either dumper trucks or conveyors.

In hard rock quarries, explosives may be used to fracture the rock or alternatively, the rock surface may be gouged by a ripper operated by an operator in a filtered cab. A bulldozer forms a small heap of stone which is transferred into dumper trucks using front-end loaders for transport to the processing plant. At the primary crusher, large boulders are pecked down to size, and the resulting mixture of rock and sand is crushed to form brick-sized remnants. This material is processed wet by a mill that grinds down to grain size (1.5 mm down to 10 micron diameter) and oversize material is recirculated.

Subsequent processing of silica sand grains differs from site to site depending upon specific requirements. Common processing activities include washing, sizing, drying and bagging of the sand grains. For specific applications, more intensive processing may be required, such as acid leaching to remove iron from the surface of the sand grains. As an illustration, the processing activities at one of the UK's most complex silica sand operations can be described as follows:

The grains enter a density gradient from where the sands are extracted. Clays and silts are discarded and the major portion (1.5 mm down to 100 micron diameter) enters a spiral area that removes heavy minerals by centrifugal force. This discarded sand is sold as 'builders' sand.' The less dense material is filtered to reduce its moisture content and the retained sand (4-7% water) is carried by conveyors to a pre-heater and reactor drum. Water and acid is added to leach away iron which could cause decolouration in subsequent applications of the sand. The sand is size-separated by "hindered settlement" and the coarser material (0.5 to 1.5 mm diameter) is used for high-grade (bunker) sand. The finer material serves three purposes for which it may be dried in a rotary drier/cooler. Sand for glass making is the principal product and most of this goes directly from storage to customers. Some sand is milled to produce quartz flour and some is calcined at high temperature to produce cristobalite before being milled to flour if required.

(a)(ii) Underground mining of silica sand

Silica sand is mined underground at one site in the UK.

(b) Silica flour production

The general production processes for silica flour are common to all sites and the following is a representative summary of the process.

To mill the sand, 40 mm diameter alumina balls are used as the grinding media in rotating mills to produce a range of products. From the storage bin, the silica or cristobalite is fed by vibration into the ball mills. The resulting product is sized and the finer material is screw-fed to silos where the material may be conveyed to hoppers and bagging plant or conveyed directly to road tankers.

These milling processes have the potential for high RCS exposures and there will inevitably be fugitive emissions forming fine layers of dust which must be removed periodically by vacuum cleaning. Owing to the fact that the process is well automated, employees are not needed in the mills for most of the day, and the major personal exposure to silica and cristobalite flours will occur during bagging. Pressurised air is added to the stream of flour to "fluidise" the movement, and this

inflates the bags and causes emissions of fine jets of flour from bag corners. LEV around the bag filler should trap these emissions before the bags are sealed and dropped down via an enclosed handling system to a palletising area which is partially enclosed in a booth with plastic strips to form a frontal perimeter. Employees in the bagging area wear RPE routinely because monitoring data showed that some exposures exceeded the current MEL of 0.3 mg.m^{-3} . A fully automated bagging plant would reduce personal exposures but cost more than £2 million per site. A less capital-intensive solution would be partial-automation (i.e. robot palletising) combined with the use of air-supplied RPE. It was noticed that some bags carried dust on the outside and would represent an RCS exposure risk for down-stream users.

The filling of “big bags” and road tankers showed lower potential for high RCS exposures during bag filling. However, consideration would need to be given to dust control problems that may result for downstream users.

There are about three companies in the UK who produce silica flour (the total number of employees is fewer than 100), and they produce less than 100,000 tonnes

(c) Usage of silica-containing industrial minerals

The downstream uses for silica and cristobalite sand/flour are many and varied and this constitutes a sector in itself. The major consuming sectors such as foundries and ceramics are dealt with in their own sections of this RIA.

Silica sand and flour is used for glass manufacture and also for grinding glass. Because of its resistance to heat and thermal expansion, it is used as filler in fine moulds, dentures, keypads, paints, scourers, insulation boards, fibreglass, grouts and road markings.

Although the list of uses is long, most companies using the flour are in the SME category. A range of uses for silica sand and flour, along with an outline of the processes involved, are given below.

Glass manufacture

As a whole, there are about 2,000 employees in the UK glass-making industry and silica sand rather than silica flour is always used in the production. At one major site, about 5,000 tonnes of silica sand are used weekly and there is a facility for extra storage for Bank Holiday working. From silos, sand is conveyed by means of either flat belt conveyors or tube conveyors (UK6) into mixers (where limestone, cullet, dolomite, sodium sulphate and sodium carbonate are added). Steam is blown through to ensure about 4% moisture content. The mixture is then fed to the furnaces through a hopper.

RCS exposure is likely to be highest at the hopper, or from cleaning and maintenance procedures in the batch plant. RCS exposure measurements taken on this site (including above the hopper) by static samplers in 1998 showed that all values were below 0.005 mg.m^{-3} . These values confirm our assumptions that the sand is generally above respirable size and does not undergo enough attrition to become respirable, as long as housekeeping schedules prevent excess build up of spillage.

Scouring powders

For use in scouring powders, the abrasive nature of the material is crucial. One such powder was examined and laboratory analysis showed that it contained about 60% crystalline cristobalite, 3% crystalline quartz and a small amount of trydimite, indicating that it was probably flux-calcined diatomaceous earth. Particle-sizing indicated that RCS made up about 7% of the total mass (and therefore a greater proportion of the total particles). The powder is either sprinkled onto a damp cloth or used as a paste but production of the powder is a source of potential exposure.

Some abrasive cleaners containing cristobalite flour are mixed at UK sites and we have assumed that there are ten. A typical company uses less than 50 tonnes of material monthly so the flour is supplied in 25-kilo bags - the small usage and sometimes planning problems preventing the use of storage silos. Bags are usually dropped into a "bag-buster" (cost £5,000) which slits the bag and drops the contents into a hopper. Extraction at the bag-buster moves dust to a collecting hopper and the empty bags are often pushed into large polythene bag for bag disposal. However, there is still a tendency for bags to be discarded nearby in a heap. The purchase of a bag-balers (cost around £6,000) would reduce RCS exposures considerably. The powders are blown into a water tank where other powders and surfactants are added to provide a wet mix. Wash-down is done wet, and cleaning is generally undertaken by vacuuming although dry sweeping may be used at some locations.

Alternative mixing processes may require ribbon mixers (cost £250,000) but the bags may be slit on the mixer. The powder spirals into an extracted hopper and then into the main production area for filling of the pots.

In the production areas, the filling of small pots of dry scourer has the potential for RCS exposure if the sealing of the pots is poor.

Methyl methacrylate composites

Another major use of silica flour is for the addition to methyl methacrylate (MMA), which is then polymerised and cured. Composites are made from MMA, polymers, fillers like aluminium trihydrate, and silica flour or cristobalite. Silica arrives in tankers and the flour is blown to storage in large silos. The flour is dehumidified to ensure a smooth flow and water hoses are available to damp down any spillages.

From storage, the flour is blown into weigh hoppers and passes through rotary valves to a reaction vessel containing the MMA syrup. From this stage, the silica flour is part of a thick syrup and unless the composite is sawn, the potential for exposure to respirable crystalline silica remains small. The syrups are moulded and

cured by customers into a wide variety of shapes, including the proverbial kitchen sink.

The bulk manufacture of MMA syrups for moulding is not likely to be a high exposure process, but many companies use silica flour in small-scale quantities, and 25-kilogram bags are regularly slit and tipped. It is here, that the potential exposures will be highest. We have no reliable data on the number of companies involved in these small-scale, mixing processes, and have estimated a total of 20 companies and possibly 500 employees.

Road markings/surfaces

Another major use for both sand and flour is for road markings/surfaces. Silica is used in coloured surfaces (8,000 tonnes annually), anti-skid coatings and encapsulated bitumen, and the main growth area is in the use of hot-applied coatings.

This use is expanding because of the hard-wearing, anti-skid nature of the products. The companies producing the bagged powders for road markings are supplied by tankers containing the main constituents – dolomite, and silica sand or flour. From storage, the powders are mixed in hoppers where resins (and occasionally calcined flint) are added. After thorough mixing, the powder is heat-sealed into 25-kilogram bags.

These bags are used by road-marking teams. A sealed mixer spreads a slurry of concrete and aggregate and the silica powders are added as bags to the heater which melts the material and spreads it. Bags are routinely split before being added, but this is probably an unnecessary risk as the bags dissolve in the heated mixture. Exposure is possible both during addition of the powder to the heater and during the removal of old road markings. When old material is removed by either scabbling or by the use of hot compressed air, the enormous dust clouds which can be produced also present a risk to passing pedestrians.

The road-marking sector has about six major companies who manufacture the thermoplastic powders containing silica flour (about 50,000 tones per annum). They employ about 100 workers in total and they are currently working on reformulating the products to remove silica flour and replace it with dolomite and magnesium carbonate wherever possible. However silica sand/flour is used because it is both cheap and a good bulking agent. The major companies spread their own product, sell some on to smaller contractors and export some. There are about 50 or 60 smaller contractors but the total employment in the sector is less than 500.

Floorings and coatings

Small companies add silica and cristobalite flour along with other aggregates to produce powders for use in coatings for flooring, roofing and walls. Often the silica flour is used in some industrial flooring products where suitable alternatives (such as aluminium trihydrate) have not been sufficiently developed. Flours (around 30% of the total aggregate) are added to epoxy resins that cure in-situ.

A typical site blends the flour with other powders in an extracted booth where the bags (25 kilo) are cut and tipped under the extraction, and the empty bags disposed of by various means. The flours may be blown under pipework to a mixer/tumbler before proceeding to a filling station. From here the blended powders are filled into plastic bags that are heat-sealed and stored for further use. In some sites, silica flour is only used sporadically - for a few hours a month.

Glass polishing

Another use of silica sand is in the grinding/polishing of special glass. A slurry of water and sand becomes finer as the glass is worn smooth on the production line. RCS exposure is reduced by movable containment and splash-boards which prevent spillage and drying out of the sand slurry. Although relatively large quantities of sand may be used (1,000 tonnes weekly at one site) the RCS exposure is well controlled.

Jewellery investment casting

Jewellery investment casting, the production of small, precious metal ornaments, is another use for silica and cristobalite flour. Between 100 and 200 small companies (up to 500 employees) use a mould of investment powder to produce small ornaments and jewellery made from precious metals. The mould is made by adding the powder to water to form a paste which dries round a wax model. The mould is heated to melt the wax and then heated further to set the mould which is then available as a template for molten metal.

The moulding powder is composed of 75% silica or cristobalite flour with the remainder being plaster and a few additives. The highest potential for RCS exposure will occur when the powder is added to form a paste.

Potential RCS exposure occurs in the casting and investment area. Segregation of the investment area will prevent contamination of outside areas, and LEV at the mixing site will reduce potential RCS exposure. Because the mixing of the powder occupies only a limited part of the day, the wearing of RPE is recommended for these times. Regular washing down of the bench areas will prevent any build-up of dust and the potential for it to be made airborne.

However, it is not believed that LEV and the use of RPE during mixing is yet routine.

Miscellaneous uses

Silica sand and flour may also be used for large-scale, niche uses. It may be added to loams to produce soil for golf courses, and because of the white colour, it can be used as filler for golf-course bunkers. We have estimated a total of 500 employees in this sector.

Construction industry

Overview of processes:-

The following tasks have been highlighted for individual consideration.

Concrete-cutting saws

Hand-held saws are used in the construction industry to cut or shape paving slabs, kerb-stones or other concrete products. The cutting action generates respirable dust which may contain a high RCS content. These saws can be powered by combustion engines, electricity or by compressed air but substitution with saws suitable for water suppression is usually possible.

Grit/sand blasting

Dry blasting and wet blasting are similar but wet blasting delivers the abrasive in a water suspension. The cleaning is carried out by a blaster, assisted by a potman who services the machine, and silica exposure can be very high. Even if the abrasive is silica-free, the blasting procedure can produce high respirable crystalline silica exposure if the material being cleaned contains silica - as it often does.

Construction or civil engineering drilling

Although the same drill pieces are used as in quarry drilling, there are minor differences in civil engineering drilling. The British Drilling Association represent about 80% of drilling operations in UK, both civil and quarry drilling. Overall, there are about 150 companies with around 2,500 drilling pieces. The civil engineering drills usually have a crew of two while most quarry drills have only with one operator. The total number of operators will be around 5,000.

Construction drilling involves chasing channels through siliceous material using a diamond-tipped drill and hence RCS exposure may be high.

Tunnelling

In traditional tunnelling, the tunnel is excavated from inside a shield. Tunnel-boring machines create their own shield and the waste rock is passed via conveyors and/or trucks to the surface. Drill and blast techniques are occasionally used. With the advent of increased mechanisation, the potential for increased RCS exposure has increased. As in quarrying, the RCS exposure is crucially dependent on the type of rock being excavated, but the adequacy of ventilation is also important to RCS exposure. BS 6164 (1990) advised that the ventilation rate in tunnelling should be at 9 cubic metres per minute per square metre of tunnel cross-section. In three of the four tunnelling sites studied by EH74/2, this was not achieved. The most recent update of this standard (BS 6164, 2001) suggests a minimum air velocity in the tunnel of 0.5 metres/second, an even higher rate.

Shotcreting, the pneumatic application of a mix of sand, cement, additive and water, is becoming more popular. The dryish mixture is blasted onto excavated walls to stabilise them but drying out and overspray means that RCS exposure can be high.

General work

This sub-sector includes a wide range of general activities connected with construction, such as "scabbling", cleaning, breaking using "pneumatic drill", brick working, and the use of sand, cement and mortar.

Polishing stone or mosaic floors is a less obvious source of RCS exposure and the application and removal of "artex" is also included here.

Stonemasonry industry

Overview of relevant processes:-

Tools used in stone working can be classified under three headings: Cutting tools in which stone is cut by the edge of a rotary disc or blade, grinding tools where an attrition surface is provided by the flat surface of a rotating disc, and chisels or percussion hammers where layered stone is split or stone broken into fragments. Of these, disc-cutting tools produce the highest exposures.

HSE guidance published in 2001 (Controlling exposure to stonemasonry dust – HSG 201) estimated the current exposures from different stonemasonry processes. Powered disc cutting and powered disc polishing can produce RCS exposures between 2 and 100 mg.m⁻³. Pneumatic chiselling is assumed to be less risky, but exposures between 0.7 and 10 mg.m⁻³ are possible, and hand chiselling is likely to produce exposures between 0.3 and 2 mg.m⁻³. However, the daily RCS exposures to stonemasons are due to a range of activities and may be highly variable – depending on the stone being cut, the tasks, the method of cutting and the controls used.

Engineering controls are used in stonemasonry, but there is still a high reliance on RPE to control high exposures, even when power tools are used. Although power chiselling has the potential to produce high respirable crystalline silica exposures, HSE's Respirable Crystalline Silica Exposure Assessment Document (EH74/2, 1999) suggested that very few operators used engineering controls, relying only on RPE.

This document also suggested that large fixed saws used wetting as a primary control, but as this also prevented damage or accelerated wear to the blade, it should not be costed under silica reduction. Although additional controls were necessary to reduce exposure below 0.3 mg.m⁻³ when cutting high silica stone, no additional engineering controls were used by the sawyers studied. Even with wet sawing, the fine mist produced is often contaminated with siliceous particles and must be suppressed. Control could be attained by a combination of mist suppression and LEV, and baffles may be needed to reduce peripheral air movement. Angle grinders used by stonemasons are smaller than those used in the construction industry and likely to be electrically powered, thus water suppression was not an option. LEV was the main control found but RPE was almost universally used. An essential control measure for stonemasons is to replace FFP3 filters on a regular basis.

Power chisels significantly increased exposure to respirable crystalline silica; of five samples taken, only one exposure was below 0.1 mg.m⁻³, and most operators relied on RPE for protection. Clothing contaminated with fine respirable dust acts as a reservoir, and when the person moves the dust may be released. Certain types of non-knitted, synthetic fibre-containing workwear release less dust than cotton, and may be more appropriate. Also, regular changes of clothing with the use of impermeable aprons are needed.

In 1997, HSE agreed to study the most cost-effective, affordable and maintainable control measures for power tools used in stonemasonry. This report (Brown, 1998) looked at available control systems. Booths were available but air-flows within the booth may be unsatisfactory and RPE may still be necessary. Down-draught

benches were suitable for some processes but information on airflow rates was often scanty. Dust extraction tools were numerous and the optimal arrangement was having the firm that designed the tool also designing the extraction. Retrofitting, although possible, was often less satisfactory. Air was usually extracted from a chamber formed by a shroud or hood of the dust collection system and the surface being cut, and the tool was contained within this. Water was principally used on saws, grinders and core borers and was often used to cool the blade as well as suppress dust. Where there was a filtration system on the tool, it only worked well with a vacuum system installed throughout the plant to which stone cutting tools could be attached.

A recent French study (Regnier et al, 2001) suggested that down-draught booths could produce a 100-fold reduction in RCS exposures from cutting and polishing using hand-held tools and formed the basis for the Silica Essentials recommendations for stonemasonry.

ANNEX 4 – EXPOSURE DATA FROM RELEVANT INDUSTRIES

Foundry

In all the sections summarising the available exposure data, there is a natural split at 1997. This is because the RCS MEL was amended in January 1997 when 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 readjusted to 0.3 mg.m^{-3} from 0.4 mg.m^{-3} when sampled by the new convention. All RCS exposure data in this document is as measured at the time, thus we have separated pre-1997 and post-1997 data.

Table 1 (Annex 1) shows pre-1997 RCS exposure data from HSE; 18% of pre-1997 values were over 0.1 mg.m^{-3} and 29% were above 0.05 mg.m^{-3} . Post-1997 HSE's NEDB (table 3, Annex 1) showed that 12% of samples were above 0.1 mg.m^{-3} , 24% were above 0.05 mg.m^{-3} and 41% were above 0.02 mg.m^{-3} .

EH74/2 (1999) states of the pre-1997 data that "Of the 273 results provided by industry, only 4 exceeded the value of the MEL." RCS exposure data from HSE is likely to be higher than industry-supplied data because HSE sampling often took place when a problem was identified.

There is no other modern data available but Castings Technology International (CTI) have been collecting RCS exposure data from foundries since the mid-1970s and intend to analyse all 25,000 data points by May 2004. However, a superficial estimate of the data suggested that over the last five years (since 1998) 10-20% of the exposures were above 0.1 mg.m^{-3} but these were controlled by the use of RPE. About 50% of exposures were above 0.05 mg.m^{-3} .

Later analyses of the 2,000 data points available since 1998 show that only 2% of the exposures were above 0.3 mg.m^{-3} , 10% of the exposures were above 0.1 mg.m^{-3} , 25% of the exposures were above 0.05 mg.m^{-3} and 75% of the exposures were above 0.01 mg.m^{-3} .

Many of the high exposures were from special operations that are more difficult to control. Of the 2% of recent RCS exposures above 0.3 mg.m^{-3} , some 40% were from processes like kiln wrecking and most of the rest from fettling operations where well-designed LEV is essential. After knockout and before shot-blasting, dirty castings with burnt-on sand may be hammered to remove the sand and provide a slot for hooks. Although well-designed and suitable extraction is essential during this process, it may not always be provided.

Ceramics

In all the sections summarising the available exposure data, there is a natural split at 1997. This is because the RCS MEL was amended in January 1997 when 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 readjusted to 0.3 mg.m^{-3} from 0.4 mg.m^{-3} when sampled by the new convention.

Table 1 (Annex 1) shows pre-1997 RCS exposure data from HSE; 43% of samples were above 0.1 mg.m^{-3} and 88% of samples were above 0.05 mg.m^{-3} . Post-1997 HSE's NEDB (Table 3, Annex 1) seems to indicate an improvement (even allowing for the change in the measurement convention) with 24% of samples above 0.1 mg.m^{-3} and 53% above 0.05 mg.m^{-3} . However NEDB data since 1997 is not only scarce, but may not be representative of typical potteries because it is weighted towards the poor performers.

Larger companies now take dust control and monitoring very seriously, and have been largely self-regulating. However, little sampling is routinely done by smaller companies. HSE undertook a survey of small and medium-sized potteries in 1997 (Guiver et al, 1998) to try to fill this gap and table 4, in Annex 1, summarises the data. Only 3% of employees performed tasks leading to respirable crystalline silica exposures above 0.3 mg.m^{-3} and the authors concluded that personal exposures in these small potteries were likely to be twice those of similar workgroups in large potteries. Highest exposures were found during dry fettling when LEV was poor and during casting when dirty moulds were used. Corresponding figures for the larger potteries (Table 5, Annex 1) showed no RCS exposures above 0.3 mg.m^{-3} .

From the 2003 HSE questionnaire (Table 10, Annex 5), it was believed that currently 0.7% of employees were exposed to RCS levels above 0.3 mg.m^{-3} , about 1% were exposed to RCS levels above 0.1 mg.m^{-3} , about 7% were exposed to RCS levels above 0.05 mg.m^{-3} and about 17% were exposed to RCS levels above 0.01 mg.m^{-3} .

Brick making and heavy clay

In all the sections summarising the available exposure data, there is a natural spilt at 1997. This is because the RCS MEL was amended in January 1997 when 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 readjusted to 0.3 mg.m^{-3} from 0.4 mg.m^{-3} when sampled by the new convention.

Table 1 (Annex 1) shows pre-1997 RCS exposure data from HSE. 37% of pre-1997 values were over 0.1 mg.m^{-3} and 63% were above 0.05 mg.m^{-3} . More modern data supplied by the industry (Table 8, Annex 1) suggests that there have been improvements in this sector. Sampling during the period 2002 to 2003 showed that of 33 samples for RCS from 3 sites, 3% were above 0.3 mg.m^{-3} , 24% were above 0.1 mg.m^{-3} and 48% were above 0.05 mg.m^{-3} .

Sampling by HSE in 2002 (before improvements) at one brick-manufacturing site which used clamp firing showed that RCS exposure to setter machine operators and to clamp setters (untabulated) varied from 0.06 to 0.46 mg.m^{-3} (8-hour TWAs).

From the 2003 HSE questionnaire (Table 10, Annex 5), it was believed that currently 0.4% of employees were exposed to RCS levels above 0.3 mg.m^{-3} , about 22% were exposed to RCS levels above 0.1 mg.m^{-3} , about 72% were exposed to RCS levels above 0.05 mg.m^{-3} and about 83% were exposed to RCS levels above 0.01 mg.m^{-3} .

Quarry

(a) Aggregates, surfacing materials

Exposure data

In all the sections summarising the available exposure data, there is a natural split at 1997. This is because the RCS MEL was amended in January 1997 when 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 readjusted to 0.3 mg.m^{-3} from 0.4 mg.m^{-3} when sampled by the new convention.

HSE's NEDB showed that post-1997 (Table 3, Annex 1) three sites had been sampled and that of the 19 samples analysed, none were above 0.3 mg.m^{-3} , 11% were above 0.1 mg.m^{-3} , 58% were above 0.05 mg.m^{-3} and 84% were above 0.02 mg.m^{-3} .

A large quarry company sent sampling data for RCS covering their sites over the period 1999 to 2003, and this is tabulated in Table 6, Annex 1. Over the five years, the percentage of samples above 0.1 mg.m^{-3} ranged from 4% to 25%, the percentage of samples above 0.05 mg.m^{-3} ranged from 13% to 28% and the percentage of samples above 0.01 mg.m^{-3} ranged from 35% to 42%.

Another quarry company sent data for RCS exposure from 2001 (untabulated), showing that for the loaders and weighbridge operators, only two of the twelve samples (from five sites) were above 0.05 mg.m^{-3} and none were as high as 0.1 mg.m^{-3} . However, there was no indication of the type of stone quarried at these sites.

(b) Slate Quarries

Exposure data

Specific data on slate splitting is sparse.

HSE sampled for two days at a slate quarry in 1998 and found that at stillages with LEV, the RCS exposures ranged from 0.12 to 0.39 mg.m^{-3} (8-hour TWAs). Further investigations showed that the LEV could reduce exposure by only between 2 and 4 fold. Lower exposures could be achieved by higher exhaust ventilation air flow, by adding flanges to captor hoods, by optimising alignment of the hoods, by adding exhaust ventilation to the stacks of slates and by minimising the stacking and banging together of slates once split.

In 2002, this quarry was revisited by HSE to investigate the effects of the improvements. At a slate splitting station with LEV but no LAD, the personal results were 0.10 mg.m^{-3} and 0.15 mg.m^{-3} on consecutive days. At another slate splitting station with both LEV and LAD, the personal results were 0.05 mg.m^{-3} and 0.08 mg.m^{-3} on consecutive days (all results as 8-hour TWAs).

Another company sent in sampling data from 2003 and all four personal samples taken from slate splitters were between 0.1 mg.m^{-3} and 0.3 mg.m^{-3} (8-hour TWAs). HSE visited the site during 2004 and they conducted their own sampling survey.

10 personal samples (all 8-hour TWAs) were taken from two roofing slate manufacturing sheds, the sawing shed, and from a driller in the quarry. The seven samples from the slate manufacturing shed ranged from 0.07 to 0.26 mg.m⁻³ the two samples from the sawing shed showed a value of 0.08 mg.m⁻³, and the sample from the quarry showed a value of 0.85 mg.m⁻³. The drillers wore FFP2 respirators but face-fitting had not been carried out. Advice on appropriate respiratory protection was given to the company as part of the overall advice.

Industrial minerals

HSE has no RCS exposure data relating solely to silica sand production but some data may be part of the total quarry information.

(a)(ii) Underground mining of silica sand

Silica sand is mined underground at one site in the UK.

At this site, there have been a series of personal samples taken. Of the 48 respirable silica samples taken since September 2000, 41 of the results recorded were less than 0.1 mg.m⁻³, 5 were between 0.1 and 0.3 mg.m⁻³ and 2 were above 0.3 mg.m⁻³. One of these was for the driller at 0.37 mg.m⁻³ and the other for the shotfirer at 0.68 mg.m⁻³. But both these values were taken from an area at which the ventilation was subsequently improved.

(b) Silica flour production

A large producer of silica flour provided RCS sampling data, and this is summarised in Table 7, Annex 1. Of the 15 samples taken over three years (2001 to 2003 inclusive), 27% were over 0.3 mg.m⁻³, 80% were over 0.1 mg.m⁻³, 87% were above 0.05 mg.m⁻³ and all were above 0.02 mg.m⁻³.

(c) Usage of silica-containing industrial minerals

There is very little RCS exposure data from the down-stream uses of silica sand/flour. Static measurements of ambient RCS taken since 2000 at one site using silica sand to polish glass ranged from less than 0.03 mg.m⁻³ to 0.09 mg.m⁻³. Personal measurements taken at the same time ranged from 0.04 to 0.10 mg.m⁻³ (8 hour TWAs) with the higher values associated with the grader operators, and this may be due to contamination of overalls.

We were supplied with data from a company packaging scouring powders containing silica flour. In 1997, a commercial sampling survey showed that the nine personal exposures to RCS ranged from 0.11 mg.m⁻³ to 1.45 mg.m⁻³ (as 8-hour TWAs), and that only poor quality RPE was worn. Highest exposures were found during the mixing process. After improvements, a later commercial survey in 2003 still showed that the mixing process produced the highest personal exposures – ranging between 0.36 mg.m⁻³ and 1.45 mg.m⁻³. Recommendations included the purchase of a bag-baler, better extraction and the temporary use of better quality RPE.

Construction

In all the sections summarising the available UK exposure data, there is a natural spilt at 1997. This is because the RCS MEL was amended in January 1997 when 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 readjusted to 0.3 mg.m^{-3} from 0.4 mg.m^{-3} when sampled by the new convention.

Table 2, Annex 1 summarises task-based RCS exposure data published in EH74/2 (pre-1997) and shows 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} .

In 1996, the American Occupational Safety and Health Administration (OSHA) examined its database on RCS – collected between 1980 and 1995. 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 less obviously risky tasks such as painting and paper hanging showed high exposures although these may have involved surface preparation.

More recently, Dutch workers recently examined the full-shift exposure to RCS in the Dutch construction industry. Although 64% of the measurements were above 0.075 mg.m^{-3} , it was considered that the effectiveness of control measures was potentially high (Nij et al, 2003). Water suppression or LEV reduced exposure by more than 70% and many workers used these, but RPE remained the most widely used control measure. The combination of several controls seemed to be needed to adequately reduce exposure below this level of 0.075 mg.m^{-3} .

An American review (Flynn & Susi, 2003) revealed that the major controls used in construction to reduce respirable RCS exposure were water suppression and LEV. However, the authors concluded that though these methods provided substantial exposure reductions, they did not reduce levels below the current ACGIH threshold limit value of 0.05 mg.m^{-3} . Certain activities were highlighted as causing high potential exposures. Mortar removal prior to repointing was investigated; with uncontrolled use of an angle grinder, ten personal samples showed RCS exposures between 1.29 and 2.8 mg.m^{-3} . The use of water suppression with LEV reduced RCS exposures considerably and an equivalent sample showed a short-term value of 0.38 mg.m^{-3} . Another study during grinding operations showed that without LEV, the respirable RCS exposure was 4.08 mg.m^{-3} ; with modified controls (adapting the grinder for use with LEV), the equivalent value was 0.306 mg.m^{-3} .

Surface grinding operations of concrete walls and floors was another major cause of elevated RCS exposures in this American review. Wet methods of control and LEV substantially reduced exposures.

This American review concluded that cutting and sawing operations on brick and concrete were the most challenging tasks to control respirable crystalline silica. Portable masonry saws in particular were highlighted. The geometric mean of five samples (Croteau et al, 2000) taken while this machine was being used was 29.16 mg.m^{-3} RCS – reduced to 1.70 mg.m^{-3} by the use of efficient LEV. Other

construction tasks cited in the review as causing high exposures were drilling, concrete mixing and cleaning.

Exposure to RCS in eight construction activities was recently investigated by another American group (Flanagan et al, 2003) and they showed that 71% of exposures exceeded 0.05 mg.m^{-3} . Highest exposures were found in surface grinding and concrete demolition but respirators used were often inadequate.

HSE's construction information sheet (CIS36rev1) tabulates a series of construction tasks with estimated RCS exposures, and these range from well below the current MEL for concrete crushing from demolition jobs where water jets are used and the operator has an enclosed cab to drilling in poorly ventilated conditions where RCS exposures of 300 times the MEL are possible.

Recently, a Dutch group (Nij et al, 2004) investigated RCS exposures in construction activities and found that of the 67 full-shift personal measurements (ranging from 0.0016 mg.m^{-3} to 4.7 mg.m^{-3}), 58% exceeded the Dutch MAC for respirable quartz (0.075 mg.m^{-3}). Most of the between-worker variation in RCS exposure was due to differences in the material being worked but epidemiological risk assessment by classification of material being worked was not considered practicable. This report highlights a major problem in assessing RCS exposure in construction; job titles, the usual grouping, used may not always reflect likely exposures.

Another recent American study (Valiante et al, 2004) looked at RCS exposure during road construction and repair, and found that 8-hour TWA results for operating a jackhammer ranged from 0.03 to 0.63 mg.m^{-3} ($n=25$) with 96% above 0.05 mg.m^{-3} . Sawing concrete, milling concrete and cleaning concrete resulted in 8-hour TWA RCS exposures above 0.05 mg.m^{-3} for 93% of the workers,

There are a wide variety of tasks in construction where RCS exposures are possible and a wide variety of work processes that affect these exposures. A summary of the major potential exposures is given below.

Concrete cutting

The majority (between 50% and 75%) of planned concrete cutting tasks are undertaken by full-time contractors, many of who are members of the trade association (the Drilling and Sawing Association). It is believed that there are about 170 contractors employing between 1000 and 2000 employees and they use predominantly diamond cutters with water suppression to cut openings in concrete for doorways, ceilings, pipe runs etc on demand. Other casual workers often hire equipment and it is likely that controls are less rigorous here.

Fortunately, cutting of concrete products like kerbs, slabs and blocks is often a short-term, intermittent exposure. An example given by the industry was of a typical exposure occurring five to six times during the day for 10 to 15 minute intervals. Exposure data is sparse but a British study (Chisholm, 1999), a continuation of an HSE Technical Development Survey, took place between 1996 and 1997 showed high RCS exposures during the use of concrete cutting saws, angle grinders without suppression or extraction and dry sweeping and removal of rubble. Factors such as the silica content of the material and weather conditions were also important and

drilling in poorly ventilated spaces produced particularly high exposures. This data reinforced earlier work and formed part of the HSE's information sheet on silica in construction (CIS 36Rev1) which suggested that drilling in poorly-ventilated undercroft could produce exposures over 300 times the MEL, and that chasing out mortar prior to repointing could produce exposures over 20 times the MEL – although these are often short term tasks. Even so, an exposure of 20 times the MEL means that a period of 25 minutes will produce an 8-hour TWA higher than 0.3 mg.m^{-3} , which suggests that even short-term sporadic tasks carry a risk of high RCS exposures.

The number of operators exposed to RCS during kerb stone cutting is difficult to calculate because the majority of the instruments are on short-term hire. One advantage of this system is that hire companies maintain the machines efficiently. They are usually fitted with 205 or 230 mm blades with diamond tips or abrasive wheels. About 80% of saws used for this purpose are hired and thus there is a continually changing pattern of use.

Exposure can be reduced by wet or dry methods of control. Wet methods spray water onto the rotating cutting disk and the water is supplied by tank or by the mains. However, provision of water for cooling/suppression is often inadequate. Dry methods involve local exhaust ventilation using the saw's guard as an extension and this is connected to an industrial vacuum cleaner. Recent work has shown that concrete cutting can expose operators to between 0.17 and 7.3 mg.m^{-3} of respirable crystalline silica (Lofgren, 1997) while cutting takes place. Water suppression is the control of choice and results in a considerable reduction in RCS exposure.

Dry-blasting

A local, unpublished 1993 HSE initiative in Scotland suggested that dry blasting produced high task-based exposures to respirable crystalline silica. In wet blasting, RCS exposure to the potman varied between less than 0.03 mg.m^{-3} and 0.32 mg.m^{-3} , and RCS exposure to the blaster varied between 0.2 mg.m^{-3} and 1.1 mg.m^{-3} . Dry blasting, as would be expected, produced much higher exposures. RCS exposure to the potman varied between less than 0.03 mg.m^{-3} and 1.1 mg.m^{-3} while RCS exposure to the blaster varied between 1.8 mg.m^{-3} and 38.4 mg.m^{-3} . High pressure, wet blasting is the best method for reducing RCS exposure.

It is now believed that dry blasting no longer occurs owing to environmental legislation.

Construction or civil engineering drilling

Civil engineering drilling is used for land investigation, and in mini-piling and underpinning. In both industry sectors, blasting and drilling is common. The Association's view is that the sector could comply with an RCS limit set at 0.1 mg.m^{-3} albeit with extra costs, but that a limit set below 0.1 mg.m^{-3} could mean a restructuring of the industry. Rotary drilling usually uses a flush medium of water, mud or foam which serves to reduce RCS exposure. Dry drilling is cheaper and can be used in some circumstances but has the potential for higher RCS exposure. The civil drilling sector would have more potential costs than the quarry sector because of the quarry sector's recent improved control record – forced on them to some extent

by environmental considerations; civil engineering drillers have transient work-sites and two weeks in one location is typical.

Tunnelling

Personal RCS exposures measured by HSE during shotcreting at a major tunnel enterprise in the late 1908s ranged up to 0.18 mg.m^{-3} (8-hour TWA), but employees wore suitable RPE.

Tunnel dust from London Underground was the subject of a recent investigation by the Institute of Occupational Medicine. This group looked at the composition of dust in London Underground stations and they found that only between 1 to 2% of the material was silica; thus they concluded that this represented no serious threat of silicosis to workers or the general public (Hurley et al, 2003). These values are lower than previous studies and probably reflect two major factors. Modern brake blocks, the wear of which produces much of the dust, contain lower quantities of quartz. More importantly, the trains use much less dynamic braking nowadays and this has resulted in brake shoe usage dropping to around 10% of that used previously.

Personal and static measurements of RCS in seventeen London underground stations were carried out recently (Burstion & Lewis, 1999). Personal RCS exposures ranged from 0.004 to 0.113 mg.m^{-3} ($n = 122$), with 13% below 0.01 mg.m^{-3} , 76% below 0.05 mg.m^{-3} and 98% below 0.1 mg.m^{-3} . Static RCS exposures ranged from 0.005 mg.m^{-3} to 0.076 mg.m^{-3} ($n = 15$), with 56% below 0.01 mg.m^{-3} , 94% below 0.05 mg.m^{-3} , and all were below 0.1 mg.m^{-3} .

Demolition and recycling of aggregate

This is a potentially dusty operation where buildings are demolished and the rubble used for hardcore (rammel). Before demolition by machines, the buildings are hand-stripped to remove plasterboard, wiring, wood and other useful materials that can be recycled.

The main controls currently are segregation of workers, water suppression and enclosed cabs with air-filters. During laying of materials, the highest RCS exposures can occur during the tipping of loads, and judicious segregation of employees from the process is required. Quarry stone is often used to provide a surface layer but may be applied damp because it is easier to compact this way – although dry layers may be sprayed with water to facilitate compaction later.

General work

The use of pneumatic breakers indoors will lead to potentially high RCS exposure. Although discouraged owing to the noise produced, the usual control method to reduce RCS exposure is a blower and this is unlikely to be very effective.

In the construction sector, the process of crushing and screening demolished materials is akin to the processes in quarrying. The numbers of employees involved are difficult to establish

During concrete scabbling, the hard surface is roughened to make a key for tiles, and this can be a very dusty operation. The best method of control is to lay surfaces that don't need scabbling. If a scabbler has to be used, an instrument with an integral dust suppressor and collector will reduce exposure, but RPE (at least FFP3 or equivalent) will be needed

Stonemasonry

In all the sections summarising the available exposure data, there is a natural split at 1997. This is because the RCS MEL was amended in January 1997 when 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 readjusted to 0.3 mg.m^{-3} from 0.4 mg.m^{-3} when sampled by the new convention.

As would be expected, the respirable crystalline silica exposure is dependent on the task and on the type of rock being cut, and this latter factor is emphasised by table 9 in Annex 1, which summarises the effect of rock type on RCS exposure – the data provided by HSE's Respirable Crystalline Silica Exposure Assessment Document (EH74/2, 1999). This document also shows that from HSE visit reports between 1992 and 1995, 46% of RCS exposures in stonemasonry were above 0.1 mg.m^{-3} , 31% were above 0.2 mg.m^{-3} and 11% were above 1.0 mg.m^{-3} .

A series of recent (2002/2003) HSE visits to stonemasonry companies revealed several sites where inexpensive improvements could be made. A site visit (2003) to a company using marble, granite and limestone to produce bathroom and kitchen worktops showed that though some equipment was wet-fed, masons used angle grinders and edge polishers without water suppression. Extraction was by flexible ducts above the workstation. Although booths are recommended (HSG 201), the use of type-H vacuum cleaners to remove dust daily, or at least the damping down of dust will reduce RCS exposure by themselves.

Another similar site visited earlier (2002), where granite was the main stone being used, revealed that RCS exposures ranged between 0.15 and 0.4 mg.m^{-3} (8-hour TWAs). Changes such as the refurbishment of extract ducts and the installation of down-draught extraction for hand tools, plus increased use of wet cutters and polishers reduced all RCS exposure to below 0.15 mg.m^{-3} (8-hour TWAs).

Visits by HSE (in 2002 and 2003) to a marble/limestone fireplace manufacturer showed all RCS exposures were below 0.07 mg.m^{-3} , a consequence more of the low silica content of the material than the efficiency of the controls - although the automated wet-cutting machines controlled dust emissions effectively. In the dry process area, the use of segregation and improved engineering controls made significant differences – a reassuring backup to HSE guidance suggesting that large-scale use of rotary tools should take place in a separate area.

ANNEX 5 – QUESTIONNAIRE RESPONSES

RESULTS OF A QUESTIONNAIRE ON RESPIRATORY CRYSTALLINE SILICA (RCS)

Approx 500 questionnaires (in total) were posted out to companies in 2003 in the industry sectors shown below.

1. Quarries
2. Foundries
3. Ceramics
4. Heavy clay/bricks
5. Construction
6. Stonemasonry
7. Slate splitting
8. General industry

Table 10 shows the summarised data from the questionnaires that were sent out to industry during 2003 asking for estimates of RCS exposure. Some of the answers were based on guesswork, some were based on monitoring, and some were a combination of both.

Table 10: Questionnaire responses. General data from HSE questionnaire on respirable crystalline silica

Industry sector questioned	Number of employees covered	Percentage of employees exposed to RCS	Percentage exposed above 0.3 mg.m ⁻³	Percentage exposed above 0.1 mg.m ⁻³	Percentage exposed above 0.05 mg.m ⁻³	Percentage exposed above 0.01 mg.m ⁻³
Quarries	12,230	21.0	0.6	3.0	3.6	7.8
Foundries	5,215	26.7	1.6	4.4	10.9	17.5
Ceramics	4,244	27.5	0.7	1.2	7.0	16.7
Brick/heavy clay	2,993	74.5	0.4	21.5	54.0	71.6
Construction	8,528	8.8	0	0	8.8	8.8
Stone masonry	187	37.4	0	0	0	2.1
Slate splitting	35	100	0	100	100	100

Industry sector questioned	Number of employees covered	Percentage of employees exposed to RCS	Percentage exposed above 0.3 mg.m ⁻³	Percentage exposed above 0.1 mg.m ⁻³	Percentage exposed above 0.05 mg.m ⁻³	Percentage exposed above 0.01 mg.m ⁻³
General industry	2,832	3.3	0.7	0.9	0.9	3.7
Industrial minerals	1,000	40.0	0.1	7.0	20.0	40.0

Table 11: Questionnaire responses. Exposure to RCS in the quarry sector.

There were 23 replies for this sector of which 4 indicated other sector involvements. Where other sectors are involved numbers are recorded for the individual sectors if it was possible to quantify them.

Quarries sector reply no	Category S (<50) M (<250) L (>250)	No of workers	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	25	25	0	0	0	25	
2	S	30	0	0	0	0	0	
3	S	5	0	0	0	0	0	
4	L	305	260	0	10	10	10	
5	S	24	24	0	0	0	12	
6	S	23	18	N/k	N/k	N/k	N/k	
7	S	17	0	0	0	0	0	
8	S	12	0	0	0	0	0	
9	M	150	150	0	0	0	10	
10	M	164	164	N/s	N/s	N/s	N/s	
11	M	150	N/s	0	N/s	N/s	N/s	
12	M	120	70	0	0	0	70	
13	S	26	21	N/s	N/s	N/s	N/s	
14	S	60	50	N/s	N/s	N/s	N/s	
15	S	15	12	N/k	N/k	N/k	N/k	
16	L	360	142	28	103	N/k	N/k	6 units
17	S	46	29	0	0	N/k	N/k	
18	M	220	130	0	0	N/k	N/k	
19	L	3650	350	0	70	175	350	1 company with 400 locations in

Quarries sector reply no	Category S (<50) M (<250) L (>250)	No of workers	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
								the UK
20	1 S 18 M 8 L	~6800**	~1200	48 (16 sites)	168 (40 sites)	232 (61 sites)	454 (110 sites)	**About 300 sites in total
21	M	20	20	0	20	20	20	
22	S	8	6	N/s	N/s	N/s	N/s	8 workers 3 quarries
Total		12230	2571 (21.0%)	76 (0.6%)	371 (3.0%)	437 (3.6%)	951 (7.8%)	

Table 12: Questionnaire responses. Estimated extra costs for the quarry sector to comply with new potential control levels for RCS

Quarries sector Reply number	No of employees	No employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m ⁻³	Extra costs required for RCS level below 0.1 mg.m ⁻³	Extra costs required for RCS level below 0.05 mg.m ⁻³	Extra costs required for RCS level below 0.01 mg.m ⁻³
1	25	25	None	None	None	Inestimable
2	30	0	N/a	N/a	N/a	N/a
3	5	0	N/a	N/a	N/a	N/a
4	305	260	None	N/k	N/k	N/k
5	24	24	None	None	None	Major expenditure
6	23	18	None	None	None	None
7	17	0	N/a	N/a	N/a	N/a
8	12	0	N/a	N/a	N/a	N/a
9	150	150	None	None	None	N/k
10	164	164	£1260 £1000 pa	N/s	N/s	N/s
11	130	90	None	None	None	£85,000 £12,000 pa
12	120	70	None	£450,000 £50,000 pa	£450,000 £50,000 pa	£1,000,000 £100,000 pa
13	26	21	N/s	N/s	N/s	N/s
14	60	10 (quarry)	N/k	N/k	N/k	N/k
15	15	12	N/k	N/k	N/k	N/k
16	360	142	£750,000	£1,000,000	£1,600,000	Unable to

Quarries sector Reply number	No of employees	No employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m ⁻³	Extra costs required for RCS level below 0.1 mg.m ⁻³	Extra costs required for RCS level below 0.05 mg.m ⁻³	Extra costs required for RCS level below 0.01 mg.m ⁻³
			£90,000 pa	£112,000 pa	N/k pa	achieve – hence massive cost
17	46	29	None	Small	N/k - expensive	N/k but very expensive
18	220	130	Small	N/k	N/k	Inestimable
19	3650	350	£10,000 capital	£7,500,000 £500,000 pa	£17,000,000 £900,000 pa	Inestimable
20	~6800 in total	~1200	None	None	£25 million plus annual running costs of £100,000	£50 million £200,000 pa running costs
21	20	20	N/k	N/k	N/k	N/k
22	8	6	N/s	N/s	N/s	N/s
Total	12,230	2571	£761,260 capital £91,000 pa	£8,950,000 capital £662,000 pa	About £44,000,000 Capital +	Inestimable

Table 13: Questionnaire responses. Health surveillance in the quarries sector

Only 2 companies were aware of respiratory problems in the workforce and it was not known if these were due to RCS.

Quarries sector Reply number	Routine health surveillance undertaken in relation to lung function etc	Findings?	Awareness of respiratory problems in workforce due to RCS	Follow up of leavers
1	Yes	No	No	No
2	Yes	No	N/a	N/a
3	Yes	No	No	No
4	Yes	Yes (1 case)	No	N/k
5	Yes	No	No	No
6	Yes	No	No	N/k
7	Yes	No	No	No
8	No	No	N/a	No
9	Yes	No	No	No

10	Yes	No	No	No
11	Yes	No	No	No
12	No	No	N/a	No
13	Yes	No	No	No
14	Yes	Yes (1 case)	N/k	No
15	No	No	N/a	No
16	Yes	No	No	No
17	Yes	No	No	No
18	Yes	Yes	No	No
19	Yes	Yes	No	No
20	Yes	No	No	Yes (partial)
21	Yes	No	No	No
22	Yes	No	No	No
23	Yes	No	No	No
Total	20 yes 3 No	2 cases	0 from RCS	1 Yes

Table 14: Questionnaire responses. Activities in the quarry sector producing RCS exposure, and the controls needed to comply with potential new limits

Quarries sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.01 \text{ mg.m}^{-3}</math>
1	General quarry activity	Dust extraction, Isolation, Robotics' Water mist, PPE	None	None	None	Not practicable - closure
2	No exposure to RCS?	N/s	N/s	N/s	N/s	N/s
3	No exposure to RCS?	N/s	N/s	N/s	N/s	N/s
4	Drilling, Sampling	Extraction, PPE Water mist	None	Air helmets	N/k	N/k
5	Routine maintenance of crushing/screening plants etc	Dust suppression, Various engineering control, PPE/RPE	None	None	None	Considerable investment in dust extraction, Vacuum systems, Dust suppression, Engineering control etc.
6	Roadways, Excavation, Washing/screening	Air conditioned cabs, PPE Training etc	None	None	None	None?
7	N/a no RCS exposure	N/a	N/a	N/a	N/a	N/a

Quarries sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <0.3 mg.m⁻³	Controls to reduce RCS exposure to <0.1 mg.m⁻³	Controls to reduce RCS exposure to <0.05 mg.m⁻³	Controls to reduce RCS exposure to <0.01 mg.m⁻³
8	N/a no RCS exposure	N/a	N/a	N/a	N/a	N/a
9	Picking belt station	Dust suppression	None	None	None	Dust extraction in closed environment
10	General quarry activity, Crushing aggregates	Dust monitoring, Personal sampling	Personal monitoring	N/s	N/s	N/s
11	Crushing of aggregates, Dust from sand stockpiles	Monitoring, PPE	None	None	None	Dust suppression and air monitoring.
12	Plant activities, Loading road tankers	Dust extraction, Water suppression, PPE	None	Improvements to dust suppression/ extraction	Improvements to dust suppression/ extraction	Improvements to dust suppression/ extraction
13	Crushing/screening of granite containing silica.	Dust suppression, PPE, Training, Filtration units	N/s	N/s	N/s	N/s
14	Sandstone working, Drilling, Cutting/sanding, Mallet/chisel work	Damping down	N/k	N/k	N/k	N/k

Quarries sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <0.3 mg.m⁻³	Controls to reduce RCS exposure to <0.1 mg.m⁻³	Controls to reduce RCS exposure to <0.05 mg.m⁻³	Controls to reduce RCS exposure to <0.01 mg.m⁻³
15	Crushing limestone, Crushing concrete	Water sprays, Enclosed systems	N/s	N/s	N/s	N/s
16	Maintenance, Inspection, Cleaning	LEV, Water spray, Surfaced roads, +ve air pressure rooms, Air cond., Isolation etc	Improvements to existing controls.	More encapsulation, More efficient dust extraction, Increased out of hours maintenance	Not practicable – redundancy/closure for 6 units	Definitely not practicable
17 and 18	General quarry operations	Damping, Plant design, Extraction, RPE, Training etc	None	Maintain current measures	Improvement on measures currently in place	Air fed suits & previous measures.
19	General quarry operations and material transport.	Encapsulation, LEV, Air cond., RPE, Isolation etc	Maintain existing measures	More LEV	Better extraction, Road sprinkler systems, Water suppression	Not practicable – closure.
20	General quarry activities (crushing, bagging, storage, loading etc)	LEV, Air cond., RPE, Wet working, Enclosures, Isolation etc	Air fed respirators, Improved extraction.	New/improved LEV, Automatic bagging	Major upgrade of systems, New bagging facility, Upgraded grinding etc etc, etc	Not feasible

Quarries sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.01 \text{ mg.m}^{-3}</math>
21	General quarry operations, Maintenance, Driving vehicles on site, Bagging etc	LEV, Dust filtration, Sealed cabs, Water sprinklers, Control cabins with +ve pressure, Upgraded roads etc.	None	Minor upgrading	Tightening of all exposure sources and general upgrading on all sites. Closure/redundancy of 5 sites.	Not feasible - closures
22	General quarry activity	Dust extraction, Water suppression etc.,	None	N/k	N/k	N/k
23	Quarry (stone masonry) activity	Dust extraction, Air fed helmets	New extraction system	New extraction system	New extraction system	Not feasible

Table 15: Questionnaire responses. Exposure to RCS in the foundry sector. There were 36 replies. 1 reply involved both the foundry and ceramics sectors.

Foundries sector reply no	Category S (<50) M (<250) L (>250)	No of workers	No of 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	HSE Comments
1	L	420	0	0	0	0	0	
2	M	105	85	0	5	30	85	
3	L	420	200	N/k	N/k	N/k	N/k	
4	L	400	250	0	0	250	250	
5	S	8	8	N/s	N/s	N/s	N/s	
6	M	116	16	0	0	0	16	
7	M	100	20	0	0	0	N/s	
8	S	30	20	N/k	N/k	N/k	N/k	
9	M	90	63	0	0	0	63	
10	M	121	0	0	0	0	0	
11	M	60	0	0	0	0	0	
12	N/k	N/s	N/s	N/s	N/s	N/s	N/s	
13	M	57	0	0	0	0	0	
14	M	67	10	0	0	0	0	
15	M	67	2	0	0	0	1	
16	L	550	0	0	0	0	0	
17	M	165	7	N/k	N/k	N/k	N/k	
18	M	130	28	0	0	10	18	
19	M	120	63	0	0	0	63	
20	S	43	15	0	15	15	15	
21	M	120	6	N/k	N/k	N/k	N/k	
22	L	700	46	12	12	12	12	Not for 8 hr days
23	M	121	71	2	12	27	32	
24	M	100	100	100	100	100	100	
25	M	90	30	0	8	12	30	
26	M	80	60	20	20	20	20	
27	S	9	9	0	0	9	9	
28	S	85	40	N/s	N/s	N/s	N/s	
29	M	140	112	11	22	45	112	

Foundries sector reply no	Category S (<50) M (<250) L (>250)	No of workers	No of 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	HSE Comments
30	M	57	0	0	0	0	0	
31	M	60	40	0	1	4	10	
32	L	310	5	N/s	N/s	N/s	N/s	
33	S	49	2	2	2	2	2	Now closed
34	S	40	0	0	0	0	0	
35	M	85	45	0	0	0	45	
36	M	100*	30	30	30	30	30	*50 in foundry
Total		5215	1383 (26.5%)	177 (3.4%)	227 (4.4%)	566 (10.9%)	913 (17.5%)	

Table 16: Questionnaire responses. Estimated extra costs for the foundry to comply with potential new control limits for RCS

Foundries sector Reply number	No of employees	No of employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m ⁻³	Extra costs required for RCS level below 0.1 mg.m ⁻³	Extra costs required for RCS level below 0.05 mg.m ⁻³	Extra costs required for RCS level below 0.01 mg.m ⁻³
1	420	0	N/a	N/a	N/a	N/a
2	105	85	None	£20,000 £7,500 pa	£60,000 £15,000 pa	Inestimable
3	420	200	None	N/k	N/k	N/k
4	400	250	None	None	£15,000 pa total cost	£250,000 cap £100,000 pa
5	8	8	None	None	None	£100,000 capital
6	116	16	None	None	None	N/k
7	100	20	None	None	None	£100,000 cap
8	30	20	N/k	N/k	N/k	N/k
9	90	63	None	None	Not viable	Inestimable
10	121	0	N/a	N/a	N/a	N/a

Foundries sector Reply number	No of employees	No of employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m ⁻³	Extra costs required for RCS level below 0.1 mg.m ⁻³	Extra costs required for RCS level below 0.05 mg.m ⁻³	Extra costs required for RCS level below 0.01 mg.m ⁻³
11	60	0	N/a	N/a	N/a	N/a
12	N/s	N/s	N/a	N/a	N/a	N/a
13	57	0	N/a	N/a	N/a	N/a
14	67	10	None	None	None	None
15	67	2	None	None	None	N/k
16	550	0	N/a	N/a	N/a	N/a
17	165	7	N/k	N/k	N/k	N/k
18	130	28	None	None	£29,900 capital £3,000 pa	£50,000 £9,800 pa
19	120	63	None	None	None	£105,000 capital
20	43	15	None	£35,000	N/k	N/k
21	120	6	£3000 £600 pa	N/k	N/k	N/k
22	700	46	£15,000	N/k	N/k	N/k
23	121	71	£8,000 £3,000 pa	Further £6,000	N/k	N/k
24	100	100	None	None	Not viable	Inestimable
25	90	30	None	£65,000 £5,000 pa	£250,000 £80,000 pa	£450,000 £25,000 pa
26	80	60	£150,000 £11,000 pa	£200,000 £20,000 pa	£5,000,000	£5,000,000
27	9	9	None	None	None	£40,000
28	85	40	£50,000	N/s	N/s	N/s
29	140	112	£180,000 £15,000 pa	£925,000 £45,000 pa	Inestimable	Inestimable
30	57	0	N/a	N/a	N/a	N/a
31	60	40	None	N/k	N/k	N/k
32	310	5	None	£75,000	N/k	N/k
33	49	2	N/a	N/a	N/a	N/a

Foundries sector Reply number	No of employees	No of employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m ⁻³	Extra costs required for RCS level below 0.1 mg.m ⁻³	Extra costs required for RCS level below 0.05 mg.m ⁻³	Extra costs required for RCS level below 0.01 mg.m ⁻³
34	40	0	N/a	N/a	N/a	N/a
35	85	45	None	None	None	£6,000 £3,000 pa
36	100*	30	N/k	N/k	N/k	N/k
Total	5215	1383 (26.5%)	£406,000	£1,326,000	£5,354,900/ inestimable	£6,101,000/ inestimable

Table 17: Questionnaire responses. Health surveillance in the foundry sector

Foundries sector Reply number	Routine health surveillance undertaken (In relation to lung function etc)	Findings?	Awareness of respiratory problems in workforce due to RCS	Follow up of leavers
1	N/a	N/a	N/a	N/a
2	No	No	No	No
3	Yes	No	No	No
4	Yes	No	No	No
5	Yes	No	No	No
6	No	No	No	No
7	No	No	No	No
8	Yes	No	No	No
9	Yes	No	No	No
10	N/a	N/a	N/a	N/a
11	N/a	N/a	N/a	N/a
12	N/a	N/a	N/a	N/a
13	N/a	N/a	N/a	N/a
14	No	N/a	N/a	N/a
15	No	No	No	Yes
16	Yes	No	No	No
17	No	N/a	N/a	No
18	Yes	Yes	No	No

Foundries sector Reply number	Routine health surveillance undertaken (In relation to lung function etc)	Findings?	Awareness of respiratory problems in workforce due to RCS	Follow up of leavers
19	Yes	No	No	No
20	Yes	No	No	No
21	No	N/a	N/a	N/a
22	Yes	No	No	No
23	No	N/a	N/a	N/a
24	Yes	No	No	No
25	Yes	No	No	No
26	Yes	No	No	No
27	No	No	No	No
28	Yes	No	No	No
29	No	No	No	No
30	Yes	No	No	No
31	Yes	No	No	No
32	Yes	No	No	Yes
33	No	No	No	No
34	N/a	N/a	N/a	N/a
35	Yes	No	No	No
36	Yes	N/s	No	No
Total	18 Yes, 8 No, 10 n/a	1 case	0 from RCS	2 Yes

Table 18: Questionnaire responses. Activities in the foundry sector producing RCS exposure, and the controls needed to comply with potential new limits

Foundries sector reply number	Activities causing rcs exposure	Current controls	Controls to reduce rcs exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.01 \text{ mg.m}^{-3}</math>
1	N/a	N/a	N/a	N/a	N/a	N/a
2	Sand moulding, Knock out, Shot blasting, Fettling	Extraction PPE (air helmets)	None	Improved extraction, Air monitoring, Changed working practices	Extraction, Enclosures, Slower work methods	Not considered possible.
3	Moulding, Casting, Coremaking, Cleaning	LEV	Possibly PPE in a few areas	Extensive – new extraction, Systems design etc	Extensive	Extensive
4	Spruing, Fettling, Handling	Extraction, PPE, Enclosures	None	None	Improved extraction, Better PPE	Greater extraction, Top of range PPE, More enclosures
5	Spraying moulds, Cleaning moulds.	Extraction, Housekeeping	None	None	None	Upgraded extraction etc
6	Sand plant, Shot blasting, Casting, Fettling	Enclosures, PPE	None	None	None	N/k

Foundries sector reply number	Activities causing rcs exposure	Current controls	Controls to reduce rcs exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.01 \text{ mg.m}^{-3}</math>
7	Coremaking, Core drilling, Casting Shotblasting, Grinding	LEV PPE	None	None	None	Substantial extraction systems
8	Furnace building,	LEV PPE	N/k	N/k	N/k	N/k
9	Knock out, Fettling, Cleaning	Extraction, PPE Housekeeping	None	Better extraction, PPE	Not viable	Not viable
10	N/a	N/a	N/a	N/a	N/a	N/a
11	N/a	N/a	N/a	N/a	N/a	N/a
12	N/a	N/a	N/a	N/a	N/a	N/a
13	N/a	N/a	N/a	N/a	N/a	N/a
14	Broken preformed refractory, Cutting, Grinding	Substitution of silica	None	None	None	None
15	Sand core making, Knocking out	Exposure monitoring	None	None	Additional ventilation, Extensive monitoring	Not possible

Foundries sector reply number	Activities causing rcs exposure	Current controls	Controls to reduce rcs exposure to <0.3 mg.m⁻³	Controls to reduce rcs exposure to <0.1 mg.m⁻³	Controls to reduce rcs exposure to <0.05 mg.m⁻³	Controls to reduce rcs exposure to <0.01 mg.m⁻³
16	Furnace -occasional repair	N/s	None	None	None	
17	Reclaiming cast metal from moulds, Furnace lining replacement	LEV Training, PPE	N/k	N/k	N/k	N/k
18	Sand mould making, Sand core manufacture, Sand core knockout	Enclosed cabinets, Extraction, PPE	N/a	N/a	N/a	Improved ventilation, Better PPE
19	Furnace knockout and build, Airmelt casting, Mould assembly, Grinding, Shotblasting	LEV	None	None	None	Upgrading of LEV etc
20	Sand mould making, Knockout, Truck traffic, Mechanical attrition, Sand manufacture	LEV Good housekeeping	None	LEV additions and replacement	Enhanced extraction systems	Not known
21	Mould knockout	LEV	Air hoods	New process required Air hoods	New process required Air hoods	New process required Air hoods

Foundries sector reply number	Activities causing rcs exposure	Current controls	Controls to reduce rcs exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.01 \text{ mg.m}^{-3}</math>
22	Furnace reline, Ladle repairs	PPE, Off site relining and ladle work	Improved PPE, Extraction	N/k	N/k	N/k
23	Core knock out, Casting, Linishing, Core making/ blasting	Bag type extraction, Roof extraction, PPE	New extraction systems,	New extraction systems,	New extraction systems,	New extraction systems,
24	Most activities (unspecified)	LEV Monitoring, RPE/PPE	None	Improve techniques and Engineering controls	Improve techniques and Engineering controls	Improve techniques and Engineering controls
25	Sand mixing/moulding, Casting knockout, Casting shot blast cleaning	Extraction	None	Increased extraction	Filtered fresh air supply, Remote operations Additional abatement plant	Total enclosure, Remote operation etc.
26	Dressing, Knock out, Cleaning	Extraction, PPE, Monitoring	Review existing controls,	Upgrade extraction, New filters/motors etc	New foundry	New foundry
27	Making sand moulds	Extraction and filter systems	None	None	None	Total enclosure, New LEV plant etc
28	Sand reclamation, Sand mixing	LEV PPE	New extraction system	N/s	N/s	

Foundries sector reply number	Activities causing rcs exposure	Current controls	Controls to reduce rcs exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce rcs exposure to <math><0.01 \text{ mg.m}^{-3}</math>
29	Grinding, Shotblasting, Cut off, Moulding, Casting, Knockout	Gas scrubber, Bag/Cartridge filters, Good housekeeping, Air flow helmets	Increased extraction facilities	New floors, Better housekeeping, Increased extraction	Extensive	Extensive
30	N/a	N/a	N/a	N/a	N/a	N/a
31	Moulding, Fettling	Extraction, PPE	None	PPE	Extraction systems	N/k
32	Knockout of sand cores	Fully enclosed equipment, Isolation of people	None	Redesign of process	N/k	N/k
33	Knockout, Sand reclamation	Extraction, PPE, Segregation	N/s (Closing down)	N/s (Closing down)	N/s (Closing down)	N/s (Closing down)
34	N/a	N/a	N/a	N/a	N/a	N/a
35	Knockout, Shotblasting, Core making, Moulding, Fettling/grinding	LEV, PPE, Monitoring	None	None	None	Everyone to wear air flow helmets
36* * Ceramics and foundry	Oven insulation Brick cutting	LEV, PPE Training	N/s for foundry	N/s	N/s	N/s

**Table 19: Questionnaire responses. Exposure to RCS in the ceramics sector.
14 replies were received from ceramics companies.**

Ceramics sector reply no	Category S (<50) M (<250) L (>250)	No of workers	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
1	M	85	6	0	0	6	6
2	M	217	90	0	0	0	25
3	M	95	31	0	0	0	31
4	L	1774	400	0	20	100	400
5	M	118	50	0	0	50	50
6	L	700	294	0	0	0	32
7	M	65	35	0	0	16	35
8	M	98	50	0	0	50	50
9	M	100	8	Not stated	Not stated	Not stated	Not stated
10	S	49	6	Not stated	Not stated	Not stated	Not stated
11	M	70	25	Not stated	Not stated	Not stated	Not stated
12	M	108	69	Not stated	Not stated	Not stated	Not stated
13	M	80	5	0	0	0	0
14	L	585	50	0	0	50	50
15	M	100	50	30	30	30	30
Total		4244	1175 (27.6%)	30 (0.7%)	50 (1.2%)	296 (7.0%)	709 (16.7%)

Table 20: Questionnaire responses. Estimated extra costs to the ceramics industry to comply with potential new control limits for RCS

Ceramics sector Reply number	No of employees	No employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m^{-3}	Extra costs required for RCS level below 0.1 mg.m^{-3}	Extra costs required for RCS level below 0.05 mg.m^{-3}	Extra costs required for RCS level below 0.01 mg.m^{-3}
1	85	6	None	None	£10,000 capital (£500 pa running cost)	£10,000 capital (£500 pa running cost)
2	217	90	None	£16,000 capital (£9,000 pa running cost)	£17,000 Capital (£12,500 pa running cost)	£18,000 capital (£18,000 pa running costs)
3	95	31	None	None	None	None
4	1774	400	None	£50,000 (£5000 per ann. running cost)	£200,000 (£20,000 pa running cost)	VERY SUBSTANTIAL!
5	118	50	None	None	£6800 (£4800 pa running costs)	£197,000 (£9400 pa running costs)
6	700	294	None	None	None	None
7	65	35	None	None	£50,000 cap	VERY SUBSTANTIAL-unobtainable!
8	98	50	None	None	£5000 (£5000 pa running cost)	VERY SUBSTANTIAL-unobtainable!
9	100	8	Not stated	Not stated	Not stated	Not stated
10	49	6	Not stated	Not stated	Not stated	Not stated
11	70	25	Not stated	Not stated	Not stated	Not stated
12	108	69	Not stated	Not stated	Not stated	Not stated
13	80	5	Minimal	Minimal	Minimal	Minimal
14	585	50	None	None	Capital cost of £100,000	Capital cost of £100,000
15	100	50				
Total	4244	1169	None	£66,000 capital	~£388,800	£325,000+ (Very substantial)

Table 21: Questionnaire responses. Routine health surveillance in the ceramics industry

Ceramics sector Reply number	Routine health surveillance undertaken in relation to lung function etc	Findings?	Awareness of respiratory problems in workforce due to RCS	Follow up of leavers
1	No	No	N/a	No
2	No	No	N/a	No
3	Not yet	No	N/a	N/a
4	Yes	No	No	No
5	No	No	N/a	No
6	No	No	N/a	No
7	Yes	No	No	No
8	Yes	No	No	No
9	Yes	No	No	No
10	Yes	No	No	No
11	No	No	No	No
12	No	No	No	No
13	Yes	No	No	No
14	Not for rcs	N/a	N/a	N/a
Total	6 Yes, 8 No	0 cases	0 for RCS	0

Table 22: Questionnaire responses. Activities in the ceramics sector producing RCS exposure, and the controls needed to comply with potential new limits

Ceramics sector Reply number	Activities causing rcs exposure	Current controls	Controls to reduce rcs exposure to <0.3 mg.m⁻³	Controls to reduce rcs exposure to <0.1 mg.m⁻³	Controls to reduce rcs exposure to <0.05 mg.m⁻³	Controls to reduce rcs exposure to <0.01 mg.m⁻³
1	Cleaning	PPE	None	None	Automated vacuum cleaning system	Automated vacuum cleaning system
2	Sponging Fettling Grinding Handling Cleaning	Dust extraction, Fettling hoods, Cleaning, PPE	Currently below 0.3	5 new fettling hoods, 8 new dust collectors	2 new dust collectors, 20 new fettling hoods	2 new more powerful dust collectors, 20 new fettling hoods
3	Casting, Sponging, Fettling, Body preparation, Kiln packing, General handling	Air monitoring, LEV tests, Wet cleaning, PPE, Safety training etc	None	None	None	Strict maintenance of fettling hoods, extraction, ergonomic factors etc
4	Cleaning, Fettling/sponging, Polishing/grinding /burnishing, Glazing/casting, Maintenance	LEV, Good housekeeping, Work methods etc	None	New and improved LEV	Vast improvements to LEV	Miracles!

Ceramics sector Reply number	Activities causing rcs exposure	Current controls	Controls to reduce rcs exposure to <0.3 mg.m⁻³	Controls to reduce rcs exposure to <0.1 mg.m⁻³	Controls to reduce rcs exposure to <0.05 mg.m⁻³	Controls to reduce rcs exposure to <0.01 mg.m⁻³
5	Sliphouse work/ Pugging, Casting/sponging Fettling, Brushing, Vibrating, Polishing, Kiln placing, Disposal of scrap Clay	Cleaning LEV PPE Safety/ Training regimes etc	None	None	Additional monitoring, Training, cleaning, water sprays, plant modifications, LEV checks to fettling hoods etc	As before along with improved checks, plant, dust lamps, surveys, pressure gauges to fettling hoods etc.
6	Sliphouse operations, Clay inspection (Casting/body prep,n)	LEV	None	None	None	None
7	Dry blending, Bag/drum filling	LEV PPE	None	On going maintenance	New dust Control eq't.	Unobtainable!
8	Silica sand used for grinding glass	Engineering controls, Housekeeping, Ceramic quality workwear, RPE, PPE	None	None	Currently near this level Maintenance/ Improvements of Existing controls	Not thought obtainable.
9	Not stated	Sand supplied damp	N/s	N/s	N/s	N/s

Ceramics sector Reply number	Activities causing rcs exposure	Current controls	Controls to reduce rcs exposure to <0.3 mg.m⁻³	Controls to reduce rcs exposure to <0.1 mg.m⁻³	Controls to reduce rcs exposure to <0.05 mg.m⁻³	Controls to reduce rcs exposure to <0.01 mg.m⁻³
10	Sponging/ Fettling Cutting	LEV Water/wet working	N/s	N/s	N/s	Cleanliness Maintenance Staff rotation Correct workwear
11 and 12	Ball milling Blunging clay Spraydryer Sliphouse operations Bone ash operations Fettling/handling	Handling in slop form	Need further survey	Need further survey	Need further survey	Need further survey
13	Batch assembly	LEV PPE	N/s	N/s	N/s	N/s
14	Fettling Milling Biscuit selecting	LEV Air monitoring	None	None	Upgrade LEV New installations	Upgrade LEV New installations

Table 23: Questionnaire responses. Exposure to RCS in the heavy clay/brick sector

Heavy clay/brick sector reply no	Category S (<50) M (<250) L (>250)	No of workers	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	M	93	70	0	30	30	30	40 < 0.01
2	M	158	96	N/s	N/s	N/s	N/s	
3	L	313	260	3	10	260	313	2 sites
4	M	205	12	0	1	1	7	3 < 0.01
5	M	90	70	N/s	N/s	N/s	70	
6	M	80	60	0	30	60	60	
7	M	249	249	5	25	249	249	
8	2S	55 (total)	14	0	10	14	14	2 sites
9	L	1750	1400	5	540	1000	1400	25 sites
Total		2993	2231 (74.5%)	13 (0.4%)	646 (21.5%)	1614 (54.0%)	2143 (71.6%)	

Table 24: Questionnaire responses. Estimated extra costs for the heavy clay/brick sector to comply with potential new control levels for RCS

Heavy clay/bricks sector Reply number	No of employees	No employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m ³	Extra costs required for RCS level below 0.1 mg.m ⁻³	Extra costs required for RCS level below 0.05 mg.m ⁻³	Extra costs required for RCS level below 0.01 mg.m ⁻³
1	93	70	None	£4,500 capital	N/k	N/k
2	158	96	N/k	N/k	N/k	N/k
3	313	260	£70,000 capital £12,000 pa	£350,000 capital £40,000 pa	N/k	Nk
4	205	12	£10,000 capital	£150,000 capital £35,000 pa	£50,000 pa	Inestimable
5	90	70	None	None	None	N/k
6	80	60	None	£100,000 capital £20,000 pa	N/k	N/k
7	249	249	£95,000 capital £25,000 pa	£380,000 capital £100,000 pa	£1,900,000 capital £500,000 pa	N/k
8	55 (total)	14	None	£1,500,000 capital	N/k	N/k
9	1750	1400	None	None	£2,900,000 capital £470,000 pa	Inestimable/impossible
Total	2993	2143 (71.6%)	£275,000 capital	£5,784,500 capital	£4,050,000+ inestimable capital	Inestimable capital

Table 25: Questionnaire responses. Routine health surveillance in the heavy clay/bricks sector

Heavy clay/bricks sector Reply number	Routine health surveillance undertaken in relation to lung function etc	Findings?	Findings in relation to RCS	Follow up of leavers
1	Yes	No	No	No
2	Yes	No	No	No
3	Yes	No	No	No
4	Yes	No (except re smoking)	No	No
5	No	N/a	N/a	N/a
6	Yes	No	No	No
7	Yes	No	No	No
8	No	Na	N/a	N/a
9	Yes	No	No	No
Total	7 Yes, 2 No	0 cases	0	0

Table 26: Questionnaire responses. Activities in the heavy clay/brick sector producing RCS exposure, and the controls needed to comply with potential new limits

Heavy clay/bricks sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.01 \text{ mg.m}^{-3}</math>
1	Sand making tiles, Grinding	LEV, Ceramic overalls, Cleaning, Maintenance, PPE Training etc	None	New LEV	New extraction system,	New extraction system etc
2	Quarrying raw materials Grinding, Conveying, Mixing, Spillage Handling Recycling	Dust suppression, Mechanical enclosure, Extraction, PPE, Road sweeper	Better PPE, Improved housekeeping, Reduce spillage, More LEV	N/s	N/s	N/s
3	LEV, PPE	Improved LEV,	Improved LEV	Increased LEV, PPE etc	Not practicable	

Heavy clay/bricks sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.01 \text{ mg.m}^{-3}</math>
4	LEV, Filtered cabs, PPE	Improved filtration units for vehicles,	Higher spec. filters for vehicles. New LEV, Spillage reduction, Covering of stock piles, Damping/washing regimes	Higher spec. filters for vehicles. New LEV, Spillage reduction, Covering of stock piles, Damping/washing regimes	Higher spec. filters etc for vehicles. New LEV, Spillage reduction, Covering of stock piles, Damping/washing regimes plus wearing of respirators for working day.	
5	Use of sand for tile shading and mould release	Cleaning and work methods	None	None	None	Best extraction available, No longer use sand
6	Hand made roofing tile manufacture	LEV Damping down Cleaning/ housekeeping PPE	None	Additional LEV Individual exhaust systems	N/k	N/k - impractical

Heavy clay/bricks sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.01 \text{ mg.m}^{-3}</math>
7	Clearing blockages in pan mil, Brick removal (from kilns) Cleaning	Ensvlosing machinery, Limitations on exposure time, Vacuum cleaner use, PPE	Significant improvements to current controls	Detailed research and investigation of practicable measures	N/k – possibly not achievable but estimate made.	Not achievable in practice
8	Brick sorting, Clay preparation, Forklift truck driving	Dust extractors, LEV	None	New methods of handling dry and fired bricks	N/k	N/k
9	Clay grinding+ processing Surface coating of bricks, Setting and de hacking	Dust extraction and collection, Dust suppression, Vacuum cleaning	None	Extensive controls re dust suppression etc	Not sure if all sites could achieve this short of PPE for all shift.	Unsure if achievable at any cost.

Table 27: Questionnaire responses. Exposure to RCS in the construction sector. Only 5 replies were received from this sector.

Heavy clay /brick 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	Housebuilding
Total		8528	750 (8.8%)	0 (0%)	0 (0%)	750 (8.8%)	750 (8.8%)	

Table 28: Questionnaire responses. Activities in the construction sector producing RCS exposure, and the controls needed to comply with potential new limits

Construction sector Reply number	No of employees	No employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m ⁻³	Extra costs required for RCS level below 0.1 mg.m ⁻³	Extra costs required for RCS level below 0.05 mg.m ⁻³	Extra costs required for RCS level below 0.01 mg.m ⁻³
1	28	0	N/a	N/a	N/a	N/a
2	3500	0	N/a	N/a	N/a	N/a
3	5000	0	N/a	N/a	N/a	N/a
4	N/s	750	None	£2000-£5000 pa	£2000-£5000 pa	£2000-£5000 pa
5	N/s	0	N/a	N/a	N/a	N/a
Total	8528	750	N/a	£2000-£5000 pa	£2000-£5000 pa	£2000-£5000 pa

Table 29: Questionnaire responses. Health surveillance in the construction sector

Construction sector Reply number	Routine health surveillance undertaken in relation to lung function etc	Findings?	Findings in relation to RCS	Follow up of leavers
1	Yes	No	No	No
2	Some (not I/func.)	No	No	No
3	No	No	No	No
4	No	No	No	No
5	N/s	N/s	N/s	N/s
Total	1 Yes	0 cases	0	0

Table 30: Questionnaire responses. Exposure to RCS in the stonemasonry sector. Only 4 replies were received from this sector.

Stonemasonry sector reply number	Category S (<50) M (<250) L (>250)	No of workers	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	9	9	N/k	N/k	N/k	N/k	
2	S	5+16=21	2+10=12	0	0	0	4	2 sites (Nos. per site N/s
3	M	70	0?	N/a	N/a	N/a	N/a	Unlikely
4	S	17	0	N/a	N/a	N/a	N/a	Unlikely?
Total		117	21	0 (0%)N/k	0 (0%)N/k	0 (0%)N/k	4 (3.4%)N/k	

Table 31: Questionnaire responses. Activities in the stonemasonry sector producing RCS exposure, and the controls needed to comply with potential new limits

Stonemasonry sector Reply number	No of employees	No employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m⁻³	Extra costs required for RCS level below 0.1 mg.m⁻³	Extra costs required for RCS level below 0.05 mg.m⁻³	Extra costs required for RCS level below 0.01 mg.m⁻³
1	9	9	N/k	N/k	N/k	N/k
2	5+16=21	2+10=12	None	None	None	£15,000 capital £600 pa
3	70	0	N/a	N/a	N/a	N/a
4	17	0	N/a	N/a	N/a	N/a
Total	117	21	N/k	N/k	N/k	£15,000 capital

Table 32: Questionnaire responses. Health surveillance in the stonemasonry sector

Stonemasonry sector Reply number	Routine health surveillance undertaken in relation to lung function etc	Any findings	Findings in relation to RCS	Follow up of leavers
1	No	N/a	N/a	N/a
2	Yes	No	No	No
3	No	N/a	N/a	N/a
4	No	N/a	N/a	N/a
Total	1 Yes, 3 No	0 cases	0	0

Table 33: Questionnaire responses. Activities in the stonemasonry sector producing RCS exposure, and the controls needed to comply with potential new limits

Stonemasonry sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <math><0.3 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.1 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.05 \text{ mg.m}^{-3}</math>	Controls to reduce RCS exposure to <math><0.01 \text{ mg.m}^{-3}</math>
1	Reconstituting stone using damp mixture to minimise exposure	Floors swept, Good ventilation, PPE	N/k	N/k	N/k	N/k
2	Shot blasting, Polishing, Cutting, Profiling, Drilling	Wet process, LEV, PPE	None	None	None	Replacement LEV New working methods, Health surveillance, New sampling and risk assessment methods
3	N/a	N/a	N/a	N/a	N/a	N/a
4	N/a	N/a	N/a	N/a	N/a	N/a

Table 34: Questionnaire responses. Exposure to RCS in the slate splitting sector. No specific replies for the slate splitting sector were received. One reply gave slate splitting as one activity along with stonemasonry and quarrying). The numbers below are for slate splitting activities only. Some quarry sector replies may contain elements of this sector.

Category S (<50) M (<250) L (>250)	No of workers	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
S	35	35	0	35	35	35
Total	35	35 (100%)	0%	100%	100%	100%

No further individual data could be ascertained.

Table 35: Questionnaire responses. Exposure to RCS in the general industry sector

General industry sector reply no.	Category S (<50) M (<250) L (>250)	No of workers	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	N/s	N/s	0	N/a	N/a	N/a	N/a	
2	M	80	45	0	0	N/k	45	3 sites
3	S	15	12	8	8	8	8	
3	S	25	0	N/a	N/a	N/a	N/a	
5	S	35	0	N/a	N/a	N/a	N/a	
6	M	60	0	N/a	N/a	N/a	N/a	
7	M	80	0	N/a	N/a	N/a	N/a	
8	S	50	0	N/a	N/a	N/a	N/a	
9	S	N/s	0	N/a	N/a	N/a	N/a	Plant closed
10	M	249	20	N/k	N/k	N/k	N/k	
11	M	128	0	N/a	N/a	N/a	N/a	
12	M	71	0	N/a	N/a	N/a	N/a	
13	L	380	6	0	6	6	6	~7

								hrs/week
14	M	183	11	11	11	11	11	
15	S	20	0	N/a	N/a	N/a	N/a	
16	S	40	0	N/a	N/a	N/a	N/a	
17	M	N/s	0	N/a	N/a	N/a	N/a	
18	L	1000	0	N/a	N/a	N/a	N/a	
19	S	60	0	N/a	N/a	N/a	N/a	2 companies
20	M	60	1	N/k	N/k	N/k	N/k	
21	M	170	0	N/a	N/a	N/a	N/a	
22	M	126	0	N/a	N/a	N/a	N/a	
Total		2832	95 (3.4%)	19 (0.7%)	25 (0.9%)	25 (0.9%)	70 (2.5%)	

Table 36: Industrial minerals sector

One reply (from a trade association) was received from the Industrial Minerals sector, which represents approximately 1,000 employees. This sector includes silica products such as silica flour and sand. Tables' 36/1 - 36/4 refer.

Table: 36/1

Industrial minerals Sector Reply No.	Category S (<50) M (<250) L (>250)	No of workers	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	3S 2M 5L	1,000	400	10	70	200	400	10 companies

Table: 36/2

Industrial minerals sector Reply number	No of employees	No employees exposed to RCS	Extra costs required for RCS level below 0.3 mg.m⁻³	Extra costs required for RCS level below 0.1 mg.m⁻³	Extra costs required for RCS level below 0.05 mg.m⁻³	Extra costs required for RCS level below 0.01 mg.m⁻³
1	1,000	400	£10,000	Varied but up to £3.4 million capital	£9 million +	Inestimable/not feasible

Table: 36/3

Industrial minerals sector Reply number	Routine health surveillance undertaken in relation to lung function etc	Any findings	Findings in relation to RCS	Follow up of leavers
1	Yes in 8 companies	None reported	No silicosis reported	No

Table: 36/4

Industrial minerals sector Reply number	Activities causing RCS exposure	Current controls	Controls to reduce RCS exposure to <0.3 mg.m⁻³	Controls to reduce RCS exposure to <0.1 mg.m⁻³	Controls to reduce RCs exposure to <0.05 mg.m⁻³	Controls to reduce RCS exposure to <0.01 mg.m⁻³
1	Quarrying, crushing, drying, screening, bagging, storage and loading, dry grinding.	LEV, air-con, PPE, enclosures, wetting, vacuum cleaning, isolation booths, positive air pressure rooms.	Air fed respirators and extraction improvement	RPE, new/improved LEV, automatic-bagging systems.	Major upgrades – automatic bagging, new silos, warehouse and roads, better grinding plants, with appropriate facilities etc	Not feasible - uneconomic

Table 37: Questionnaire responses. Summary tables on employee exposure to RCS for all sectors:

Sector	Total No. of workers Surveyed/ Sector	Total Exp RCS	0.3 mg.m⁻³ RCS or above	0.1 mg.m⁻³ RCS or above	0.05 mg.m⁻³ RCS or above	0.01 mg.m⁻³ RCS or above
Slate-splitting	35	35 (100%)	0 (0%)	35 (100%)	35 (100%)	35 (100%)
Stonemasonry	117	21 (17.9%)	0 (0%)	0 (0%)	0 (0%)	4 (3.4%)
General industry	2832	95 (3.4%)	19 (0.7%)	25 (0.9%)	25 (0.9%)	105 (3.7%)
Heavy clay/bricks	2993	2231 (74.5%)	13 (0.4%)	646 (21.5%)	1614 (54.0%)	2143 (71.6%)
Ceramics	4244	1169 (27.5%)	30 (0.7%)	50 (1.2%)	296 (7.0%)	709 (16.7%)
Foundry	5215	1393 (26.7%)	185 (1.6%)	227 (4.4%)	566 (10.9%)	913 (17.5%)
Construction	8528	750	0	0	750	750
Quarries	12230	2571 (21.0%)	76 (0.6%)	371 (3.0%)	437 (3.6%)	951 (7.8%)
Industrial minerals	1,000	400 (40.0%)	10 (0.1%)	70 (0.7%)	200 (20.0%)	400 (40.0%)

Table 37: Questionnaire responses. Summary table of estimated costs for all sectors to comply with potential new RCS limits

Sector	Total No. of workers Surveyed/ Sector	Total Exp RCS at any level	Costs for 0.3 mg.m⁻³ RCS or above	Costs for 0.1 mg.m⁻³ RCS or above	Costs for 0.05 mg.m⁻³ RCS or above	Costs for 0.01 mg.m⁻³ RCS or above
Slate-splitting	35	35 (100%)	N/k	N/k	N/k	N/k
Stonemasonry	117	21 (17.9%)	N/k	N/k	N/k	£15,000 capital (N/k)
General industry	2832	95 (3.4%)	N/k	N/k	N/k	N/k
Heavy clay/bricks	2993	2231 (74.5%)	£275,000 capital	£5,784,500 capital	£4,050,000+ inestimable capital	Inestimable capital

Ceramics	4244	1169 (27.5%)	None	£66,000 capital	~£388,800	£325,000+ (Very substantial !)
Foundry	5215	1393 (26.7%)	£406,000	£1,326,000	£5,339,900 inestimable	£5,956,000 inestimable
Construction	8528	750	N/a	£2000- £5000 pa	£2000- £5000 pa	£2000- £5000 pa
Quarries	12230	2571 (21.0%)	£ capital £ pa	£ capital £pa	£44,050,000 capital £1,050,000 pa	£60,000,000 capital (inestimable)

Annex 6 – Glossary of terms

ACGIH: American Conference of Industrial Hygienists

ACTS: Advisory Committee on Toxic Substances.

BA: Breathing Apparatus.

CEN: European Committee for Standardisation.

CIS: Construction Information Sheet.

COSHH: Control of Substances Hazardous to Health.

CTI: Castings Technology International.

DWP: Department of work and Pensions.

EMM: Enforcement Management Model.

EPS: Enforcement Policy Statement.

IARC: International Agency for research on Cancer.

ISO: International Organisation for Standardisation.

LAD: Local Air Displacement.

LEV: Local exhaust ventilation.

MDHS: Methods for the Determination of Hazardous Substances.

MEL: Maximum Exposure Limit.

MMA: Methyl Methacrylate.

NATM: New Austrian Tunnelling Method.

NEDB: National Exposure Data Base.

NIOSH: National Institute for Occupational Safety and Health.

OES: Occupational Exposure Standard.

OFT: Office of Fair trading.

OSHA: Occupational Safety and Health Administration

PEL: Permissible Exposure Limit.

PPE: Personal Protective Equipment.

QPA: Quarry Products Association.

RCS: Respirable Crystalline Silica.

RIA: Regulatory Impact Assessment.

RPE: Respiratory Protective Equipment.

SBS: Small Business Service.

SCOEL: EU Scientific Committee on Occupational Exposure Limits.

SMEs: Small and Medium-sized Enterprises

TEM: Transmission Electron Microscopy.

TLV: Threshold Limit Value.

TWA: Time Weighted Average.

WATCH: Working Group on the Assessment of Toxic Chemicals.

WEL: Workplace Exposure Limit.

XRD: X-ray diffraction.”