Respirable crystalline silica – a failure to control exposure!

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Abstract: Several sites were visited to monitor stonemason exposure to respirable crystalline silica (RCS), inhalable dust and respirable dust. At all sites, exposure to RCS exceeded the Workplace Exposure Limit of 0.1 mg/m$^3$ 8-hour TWA. There was therefore a continuing high risk of workers developing silicosis unless the appropriate measures were instigated to prevent or control exposure. Exposure control was ineffective at all sites e.g. water wall extraction systems were not well designed. There was evidence that foreign workers were at a greater exposure risk. But even with appropriate controls to mitigate exposure to RCS it may not be possible to sustain exposure to below 0.1 mg/m$^3$ 8-hour TWA without on-going HSE intervention.

1. Introduction
There has been an increase in the number of companies in the UK carrying out stonemasonry work. This has lead to a subsequent increase in the risks of developing silicosis in particular progressive silicosis.

As part of a Health and Safety Executive (HSE) enforcement initiative, in 2007 several site visits were made to companies in North East England to measure stonemason exposure to respirable crystalline silica (RCS), inhalable dust and respirable dust and to assess the measures used to prevent or mitigate exposure to stone dust.

There was evidence that during stonemasonry work exposure to RCS could not be controlled to below the Workplace Exposure Limit (WEL) of 0.1 mg/m$^3$ 8-hour Time Weighted Average (TWA) or exposure to inhalable dust and respirable dust to below 10 mg/m$^3$ and 4 mg/m$^3$ 8-hour TWAs respectively (occupational exposure limits for the dusts). There was also evidence that foreign workers mainly Eastern European were at a greater exposure risk.

2. Methods
Seven sites were visited. Most of the sites employed over five workers but not all workers were involved with stonemasonry work. The stonemasonry work at each site varied but included mainly ornamental/architectural work and the cutting of fire surrounds. Almost all the stonemasons worked for a full 8-hour shift. Eastern European stonemasons (mainly from Poland) tended to work excess overtime, worked unsupervised and were therefore at a greater risk of exposure.

Stonemasons and other relevant workers were sampled to measure exposure to RCS, inhalable dust and respirable dust using the methods as outlined in MDHS 14/3 “General methods for sampling and analysis of respirable and inhalable dust”. The RCS analysis was carried out using x-ray diffraction and as outlined in MDHS 101 “Crystalline silica in respirable airborne dusts”.

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The measures taken by each company to prevent or control exposure to dust were assessed in particular the use of water wall extraction systems.

3. Results
Table 1 lists the exposure controls at each site. In general the water wall extraction systems were not effective at capturing dust because of poor design e.g. insufficient enclosure and poor maintenance. There was widespread evidence that stonemasons who wore RPE (mainly disposable half-face dust masks) had not been face fit tested and that most of them had not been trained on their use.

Most companies did not provide adequate health surveillance and training. Because of the lack of effective measures to prevent or control exposure to RCS during stonemasonry work all workers were at a high risk of developing respiratory disease in particular the Eastern European workers who tended to have communication problems and were not familiar with working conditions in the UK.

Table 2 shows the distribution of the 8-hour TWAs for all the personal samples collected i.e. RCS, inhalable dust and respirable dust. Interestingly, 50% of all the personal samples collected to measure exposure to RCS were above 0.1 mg/m$^3$ 8-hour TWA and therefore exceeded the WEL.

The ranges and the geometric means of the personal inhalation exposures to RCS, inhalable dust and respirable dust at each site i.e. 8-hour TWAs are given in Table 3. At six sites the geometric means for RCS were above 0.1 mg/m$^3$ 8 hour TWA (for all sites it was 0.14 mg/m$^3$ 8-hour TWA). The two companies with the highest geometric mean personal exposures to RCS i.e. A and G had evidence of silicosis. The maximum exposures to inhalable dust at these two sites were very high i.e. at A – 134.7 mg/m$^3$ 8-hour TWA and at G - 120.2 mg/m$^3$ 8-hour TWA whereas exposure to respirable dust was high at only one of these sites i.e. A - 12.8 mg/m$^3$ 8-hour TWA.

Enforcement action has been taken against all companies to mitigate exposure to RCS. Two of the companies have been prosecuted.

4. Discussion
The monitoring survey indicated that during stonemasonry work the WEL for RCS was exceeded at all sites thereby increasing the worker risks of developing lung disease (including lung cancer?). Recent evidence suggests that the higher the exposure to RCS the greater the risk of silicosis. The risk rises faster the higher the exposure i.e. it is multiplicative. At the two sites with the highest exposures to RCS and inhalable dust, stonemasons had developed silicosis.

The situation in the North East of England is likely to be repeated elsewhere. There are therefore thousands of workers who may be exposed to significantly high levels of RCS. The number of cases of silicosis in the UK is likely to increase. This is especially important for foreign stonemasons who are at a particular high risk of dust exposure because they tend to work long hours, have poor communication with their employers and lack the necessary training that leads to the use of inappropriate controls.

There was a lack of knowledge by employers on the risks associated with stonemasonry work. This was reflected in the poor training given to employees, on the implementation of ineffective controls (in particular the widespread use of inappropriate water wall extraction systems) and on the failure to provide adequate health surveillance and suitable and sufficient risk assessments.

HSE will need to continue to develop its corporate strategies e.g. enforcement to ensure that the risks to stonemasons of developing silicosis are significantly reduced nationally. Such an approach will be critical if the WEL for RCS is reduced to 0.05 mg/m$^3$ 8-hour TWA at some stage in the future. Furthermore, there will need to be employer/employee behavioural changes to ensure that the measures used to mitigate exposure to RCS are sustained in the long-term.
5. Conclusions
Many stonemasons are exposed to high levels of RCS and other dusts during work activities. Unless the appropriate exposure control measures are implemented for example, the use of effectively designed and well maintained LEV systems, the use of water suppression, the use of on-tool extraction for powered hand tools and the wearing of appropriate RPE/PPE, it is highly likely that the WEL for RCS will continue to be exceeded. But even with appropriate controls it may not be possible to sustain exposure to below 0.1 mg/m$^3$ 8-hour TWA without on-going HSE intervention.
| Site | Local exhaust ventilation (LEV) | Respiratory protective equipment (RPE) | Personal Protective Equipment (PPE) | Other Controls | Comments |
|------|--------------------------------|--------------------------------------|-----------------------------------|----------------|----------|
| A.)  | Two external (covered) working areas with no LEV (for Polish workers).<br>Two inside areas with ineffective water wall extraction systems.<br>Enclosed booth for smoothing/polishing of stonework together with some carving and shaping. It was not effective. The LEV had not undergone thorough examination and testing. | Disposable half-face dust mask respirator with FFP3 classification.<br>No face fit testing had been carried out.<br>Storage boxes had recently been provided for the RPE to be stored in. | Safety boots, goggles and ear defenders. | Water cooled saws. | Poor health surveillance and training. |
| B.)  | A water wall extraction system was installed but it was not in use. No other LEV used | Disposable half-face mask with FFP3 classification.<br>No face fit testing had been carried out. | Safety boots and ear defenders. Waterproof coveralls for the wet polishers. | Water cooled saws and wet polishing. | Poor health surveillance and risk assessments. |
| C.)  | In the hand masonry area flexible ducting with capturing hood. This had undergone thorough examination and testing i.e. COSHH Reg 9. | Disposable half-face masks with FFP3 classification.<br>No face fit testing had been carried out | Safety shoes, ear defenders and eye protection. Workers wore their own clothes and overalls that were laundered at the site. | Water cooled saws. | Health surveillance carried out. No effective training. |
Table 1: Details of Exposure Controls in use at each site

| Site | Local exhaust ventilation (LEV) | Respiratory protective equipment (RPE) | Personal Protective Equipment (PPE) | Other Controls | Comments |
|------|---------------------------------|----------------------------------------|-------------------------------------|----------------|----------|
| D.)  | In the hand masonry area flexible ducting with capturing hood used. It was ineffective. This had not undergone thorough examination and testing as per regulation 9 of COSHH. | In the brick making area a disposable half-face dust mask FFP3 was worn by all the workers. No face fit testing had been carried out. | Safety boots, eye protection, rigger gloves, hi-visibility vests and hearing defenders. In the brick making area the workers wore their own clothing. In the hand masonry area disposable coveralls were used. | Water cooled saws. | No health surveillance carried out. Unsuitable and insufficient risk assessments. |
| E.)  | Two inside areas had water wall extraction systems. They were not effective. | Disposable half-face dust mask FFP2 was worn by all the workers in the brick making area. Face fit testing had been carried out. | Safety shoes/boots, overalls, hi-visibility vests and hearing defenders. The overalls were supplied by the company who also were responsible for their laundering. | Water cooled saws and wet polishing. | No health surveillance carried out. |

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| Site | Local exhaust ventilation (LEV) | Respiratory protective equipment (RPE) | Personal Protective Equipment (PPE) | Other Controls | Comments |
|------|---------------------------------|--------------------------------------|------------------------------------|----------------|---------|
| F.)  | A partially enclosed extraction booth had been recently installed. Some powered tools had extraction. | Powered (fan assisted) RPE and disposable half-face dust masks FFP3 worn. Face fit testing had been carried out where appropriate. | Overalls, safety boots and rubber palmed fabric gloves. The company had recently introduced arrangements for the laundering of work wear. | Water cooled saws and manual application of water when polishing. | Unsuitable risk assessment. |
| G.)  | One water wall extraction system in use. It was not very effective. It was used by the masons using powered tools only; there was no LEV for the masons using non-powered hand tools | Disposable half-face dust mask FFP3. The masons had not been face fit tested. | Low dust release disposable overalls, safety shoes and ear defenders. | Water cooled saws. | No health surveillance carried out. |
Table 2: Distribution of the 8hrTWA exposures for all the samples collected

| Sample Type     | Exposure levels 8hr TWA mg/m³ | Percentage of samples (%) |
|-----------------|-------------------------------|---------------------------|
| Inhalable Dust  | <=10                          | 62.4                      |
|                 | > 10                          | 37.6                      |
| Respirable Dust | <= 4                          | 89.6                      |
|                 | > 4                           | 10.4                      |
| RCS             | <= 0.05                       | 29.2                      |
|                 | > 0.05 to <= 0.1              | 20.8                      |
|                 | > 0.1 to <= 0.3               | 19.7                      |
|                 | > 0.3                         | 30.3                      |

Check Sum                  | 100

| RCS | <= 0.05 | 29.2 |
|     | <= 0.1  | 50   |
|     | <= 0.3  | 69.7 |
Table 3: The ranges and the geometric means of personal exposure to RCS, inhalable dust and respirable dust

| Site | Number of samples and sample type | Inhalable Dust 8hr TWA mg/m³ | Respirable Dust 8hr TWA mg/m³ | Respirable Crystalline Silica 8hr TWA mg/m³ |
|------|----------------------------------|------------------------------|-------------------------------|---------------------------------------------|
|      |                                  | Min  | Max  | Geo Mean | Min  | Max  | Geo Mean | Min  | Max  | Geo Mean |
| All Sites | 38(Respirable Dust) 36(RCS) 36(Inhalable Dust) | 0.26 | 134.700 | 6.84 | 0.015 | 12.800 | 0.420 | 0.010 | 4.120 | 0.14 |
| C.) | 7 (Resp Dust+RCS) 5 (Inhalable Dust) | 1.9 | 16. | 4.65 | 0.06 | 0.54 | 0.21 | 0.04 | 0.23 | 0.09 |
| F.) | 1 (Resp Dust, RCS and Inhalable Dust) | 6.3 | 6.3 | 6.3 | 0.18 | 0.18 | 0.18 | 0.12 | 0.12 | 0.12 |
| E.) | 9 (Resp Dust, RCS and Inhalable Dust) | 0.26 | 24.90 | 1.51 | 0.02 | 2.51 | 0.10 | 0.01 | 1.10 | 0.03 |
| B.) | 4 (Respirable + inhalable Dust) 3 (RCS) | 2.11 | 36.65 | 6.75 | 0.42 | 8.34 | 1.40 | 0.05 | 0.26 | 0.11 |
| A.) | 9 (Resp Dust, RCS and Inhalable Dust) | 2.70 | 134.7 | 26.39 | 0.25 | 12.80 | 1.199 | 0.09 | 4.12 | 0.89 |
| D.) | 6 (Resp Dust, RCS and Inhalable Dust) | 1.700 | 46.80 | 7.61 | 0.23 | 0.99 | 0.42 | 0.04 | 0.79 | 0.14 |
| G.) | 2 (Resp Dust, RCS and Inhalable Dust) | 6.8 | 120.2 | 28.59 | 0.18 | 0.66 | 0.34 | 0.06 | 0.49 | 0.17 |