Building an industry-wide occupational exposure database for respirable mineral dust – experiences from the IMA Dust Monitoring Programme

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Abstract: Building an industry-wide database with exposure measurements of respirable mineral dust is a challenging operation. The Industrial Minerals Association (IMA-Europe) took the initiative to create an exposure database filled with data from a prospective and ongoing dust monitoring programme that was launched in 2000. More than 20 industrial mineral companies have been collecting exposure data following a common protocol since then. Recently in 2007 ArboUnie and IRAS evaluated the quality of the collected exposure data for data collected up to winter 2005/2006. The data evaluated was collected in 11 sampling campaigns by 24 companies at 84 different worksites and considered about 8,500 respirable dust measurements and 7,500 respirable crystalline silica. In the quality assurance exercise four criteria were used to evaluate the existing measurement data: personal exposure measurements, unique worker identity, sampling duration not longer than one shift and availability of a limit of detection. Review of existing exposure data in the IMA dust monitoring programme database showed that 58% of collected respirable dust measurements and 62% of collected respirable quartz could be regarded as ‘good quality data’ meeting the four criteria mentioned above. Only one third of the measurement data included repeated measurements (within a sampling campaign) that would allow advanced statistical analysis incorporating estimates of within- and between-worker variability in exposure to respirable mineral dust. This data came from 7 companies comprising measurements from 23 sites. Problematic data was collected in some specific countries and to a large extent this was due to local practices and legislation (e.g. allowing 40-h time weighted averages). It was concluded that the potential of this unique industry-wide exposure database is very high, but that considerable improvements can be made. At the end of 2006 relatively small but essential changes were made in the dust monitoring protocol and the data collection sheet. In addition a system of quality control was set up and each new set of data is thoroughly investigated before inclusion into the database. Recently, it became apparent that more than 80% of the measurement data collected since winter 2005/2006 is of high quality. The IMA Dust Monitoring Programme Database contains personal measurements of more than 2,000 monitored workers who are representative of in total 5,000 workers in the industrial minerals production. This unique prospective exposure database will prove to be very valuable when health effects due to exposure to respirable mineral dust among these workers will be evaluated in the future.
1. **Introduction**

Building an industry-wide database with occupational exposure measurements of silica dust is a challenging operation. The Industrial Minerals Association (IMA-Europe) took the initiative to create an exposure database filled with data from a prospective and ongoing dust monitoring programme that was launched in 2000.

The IMA hygiene or dust monitoring programme aims at collecting representative and comparable dust exposure data at the level of the industrial minerals sector across Europe to be able to discuss on both industry level and on company level on the compliance with current occupational exposure limits, to develop prevention strategies to reduce exposure, to check the efficiency of implemented control measures (e.g. by studying time trends in silica dust exposure), and to be able to discuss with authorities on setting future occupational exposure limits. In addition, the exposure database could be used in the future to elaborate a job-exposure matrix for a potential epidemiological study of health effects of respirable crystalline silica.

This extended abstract describes the requirements, experience, and first results of the IMA dust monitoring database.

2. **Methods**

2.1. **Dust monitoring protocol minimal requirements**

The occupational exposure database should only contain comparable and high quality data. Therefore, all data should comply with minimal requirements to be included in the database:

- Collect 6 dust samples per job function per site per campaign (the number of six samples was chosen as a compromise between statistical needs and practical feasibility for participating companies)
- The protocol includes a list of thirteen common job functions in the industrial minerals sector (see table 1)
- Recommendation to start with two campaigns per year (Summer and Winter);
- All data should be based on personal monitoring only;
- Respirable dust fraction;
- Sampling duration should correspond to a full shift (6-8 hours)
- Allocate a unique code to each individual worker, to allow appropriate statistical analysis of time trends and cumulative exposure following repeated measurements;
- Sampling equipment must be in conformity with the European standard EN 481. Several respirable dust samplers are allowed by the protocol (e.g. CIP-10, Respicon particle sampler, Dorr-Oliver 10 mm nylon cyclone, Higgins-Dowell cyclone). Based on an international comparison study for respirable dust samplers, the allowance of different sampling equipment will introduce only small differences in absolute measured values [1]. In addition, corrections are possible in the statistical analyses by introducing sampling equipment as fixed effect in the linear mixed models;
- Provide field blanks for each sampling campaign (for quality control and for calculation of limits of detection);
- Analytical technique: Either X-ray diffraction or Fourier Transform Infrared Spectroscopy. Information on the limit of detection of the analytical techniques should be available and the laboratories involved should join an inter-laboratory round exercise;
- Record observations of work activities and factors affecting exposure during each sampling period;
- Transmit the data through a standardised MS Excel® collection sheet with standardized variable codes
A detailed protocol on all these items is available for participating companies and periodically training sessions have been and are organized for participants to learn and discuss the dust monitoring protocol.

Table 1. List of job functions within the protocol

| Job function                  |
|-------------------------------|
| 1 Quarry operator             |
| 2 Crusher operator            |
| 3 Wet process operator        |
| 4 Dry process operator        |
| 5 Miller operator             |
| 6 Bagging operator            |
| 7 Transport / bulk loading    |
| 8 Foreman / plant management staff |
| 9 Maintenance                 |
| 10 Multi-skilled operator     |
| 11 Laboratory workers         |
| 12 Research & Development     |
| 13 Plastification             |

2.2. Quality control procedure
Before inclusion in the final database, all data is extensively checked to verify if data meet all requirements and if all information is complete and internally consistent. If relevant, this step is followed by communication with company representatives and changes to the data will be made, if needed. The quality control procedure was intensified during the 11th campaign, when Arbo Unie and IRAS took over the management of the Dust Monitoring Programme.

2.3. Participation
A total of 85 different worksites of 24 industrial mineral companies from 13 countries (Belgium, Denmark, Finland, France, Germany, Greece, Italy, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom) have submitted exposure monitoring data since the start of the project. This represents a population of approximately 5,000 workers, whose job functions are covered by the protocol. The companies produce bentonite, clays, feldspar, kaolin, silica, talc, and other industrial minerals. Several participants were small and medium sized enterprises (SME’s). Both large and small companies very well managed to run the sampling campaigns within the programme.

2.4. Feed back of sampling results to companies and industry
All companies are receiving site-specific reports per campaign containing the statistical evaluation of the measurements to check with national exposure limits, to identify problem areas and job titles with high exposure levels within their company in order to develop prevention strategies to lower exposure levels. This feed-back on company level is one of the benefits stimulating companies to participate. Once every year an industry-wide report is being produced for IMA-Europe (and the participating companies) containing more sophisticated analyses on all available data. Importantly, however, all company data are treated confidentially and individual companies cannot be identified in this report.
3. Results

3.1. Available data and data quality

Recently in 2008 Arbo Unie and IRAS evaluated the quality of collected exposure data up to summer 2007 (14 sampling campaigns). A substantial body of data has been collected since the first campaign in 2002: a total of 10,207 respirable dust samples, with 8,533 of these being analysed for crystalline silica are present in the IMA-DMP database. Approximately 1,000 – 1,500 new personal exposure measurements are currently being collected annually. Table 2 presents an overview of the number of samples per country currently available.

Review of existing exposure data in the IMA dust monitoring programme database showed that 83% of collected respirable dust measurements and 80% of collected respirable quartz could be regarded as ‘good quality data’ meeting at least three crucial quality criteria (personal exposure measurement, sampling duration in accordance with protocol requirements and availability of information on limit of detection). The percentage of ‘good quality data’ considerably improved over time after the introduction of the strict quality control procedures. Problematic data was collected in some specific countries and to a large extent this was due to local practices and legislation (e.g. allowing 40-h time weighted averages).

Only 34% of the measurement data included repeated measurements of identifiable workers (within a sampling campaign) that would allow advanced statistical analysis incorporating estimates of within- and between-worker variability in exposure to respirable (crystalline silica) dust. This data came from 18 companies comprising measurements from 10 countries. Due to the improved quality control procedures, exposure data suitable for advanced statistical analysis has increased sharply to 85% in the last two campaigns.

Table 2. Number of data in the IMA DMP database per country

| Country             | Respirable dust | Respirable quartz |
|---------------------|-----------------|-------------------|
| Belgium             | 841             | 623               |
| Denmark             | 26              | 26                |
| Finland             | 209             | 115               |
| France              | 2,335           | 1,949             |
| Germany             | 1,287           | 1,287             |
| Greece              | 87              | 55                |
| Italy               | 440             | 327               |
| The Netherlands     | 834             | 395               |
| Norway              | 110             | 103               |
| Portugal            | 99              | 99                |
| Spain               | 829             | 550               |
| Sweden              | 108             | 108               |
| United Kingdom      | 3,002           | 2,896             |
| TOTAL               | **10,207**      | **8,533**         |

3.2. Trends in exposure concentrations over time

Time trends were studied on a subset of the total database (about one-third of the data), using data that met all the necessary requirements (personal sampling, sampling duration, unique worker codes available, ≥ 5 samples per cell, ≥ 2 workers per cell, and number of observations divided by number of workers ≥ 1.25). Time trends were studied using linear mixed effects models. For several minerals (e.g. silica, clay, mixed minerals), considerable and statistically significant downward trends (up to
14.5% decrease in exposure per campaign) in both respirable dust and respirable quartz concentrations could be found. As an example, the trend in respirable dust concentrations is showed in figure 1, for sites working with the mineral silica. The estimated time trend per campaign was -13.0 % (95%-confidence interval: 11.6% - 14.5%).

The number of groups of workers (defined by function and site) with overexposure were a factor of three higher for respirable quartz than for respirable dust, indicating that achieving compliance with existing OEL’s for respirable quartz is more difficult than achieving compliance with OEL’s for respirable dust. Interestingly, this number has declined rapidly in the first part of the programme and leveled off in the more recent campaigns.

![Silica Box plots represent distribution, median and mean of observed dust concentrations. The estimated time trend in dust concentrations is based on the observed dust concentrations and corrected for influences of site and job title.](image)

**Figure 1.** Trend in respirable dust concentrations for mineral silica

4. Conclusions
It was concluded that the potential of this unique industry-wide exposure database is very high. Both large companies and SME’s are able to make contributions to the exposure database. Importantly, however, a stringent quality control of incoming data is crucial. At the end of 2006 relatively small but essential changes were made in the dust monitoring protocol and the data collection sheet. In addition, a system of quality control was set up and each new set of data is thoroughly investigated before inclusion into the database. Recently, it became apparent that more than 80% of the measurement data collected since winter 2005/2006 is of high quality.
The IMA Dust Monitoring Programme Database contains personal measurements of more than 2,000 monitored workers who are representative for a total of 5,000 workers in the industrial minerals production in Europe. This unique prospective exposure database will prove to be very valuable when health effects due to exposure to respirable crystalline silica among these workers will be evaluated in the future. This study shows that it is possible to build a multi-national industry-wide exposure database in which data from SMEs is included which may serve as an example for other industries.

References
[1] Gömer P, Wrobel R, Micka V, Skoda V, Denis J and Fabriès 2001 Study of fifteen respirable aerosol samplers used in occupational hygiene Ann Occup Hyg 45 43-45