

Background

A method for evaluating respirable dust content in bulk products

SWeRF, a standard method commonly adopted by industry.

To be able to answer the common question “how much Respirable Crystalline Silica is contained in this bulk product”, the IMA Metrology WG developed the **SWeRF** – Size-Weighted Respirable Fraction – concept. It is a method to provide an indication of the content of particles in a bulk product which, if made airborne and subsequently inhaled, might penetrate the deep lung.

Dust is a potential health hazard when it is inhaled and when the particles are small enough to enter deep into the gas exchange regions of the lungs. Not every inhaled particle will penetrate into the alveoli but the probability is higher for a smaller particle than for a larger one.

Definitions: A respirable particle is a particle that is small enough to be able to penetrate into the unciliated airways.

SWeRF: Size Weighted Respirable Fraction

SWeRF_{CS}: Size Weighted Respirable Fraction of Crystalline Silica (CS)

Fraction of respirable particles

Consider two samples with a different size distribution (their characteristics are illustrated in figures 1 and 2). Both materials contain no particles larger than 16 μm , which means that all particles could reach the alveoli when inhaled. Both samples have the same amount/fraction of particles in the 0–16 μm size range.

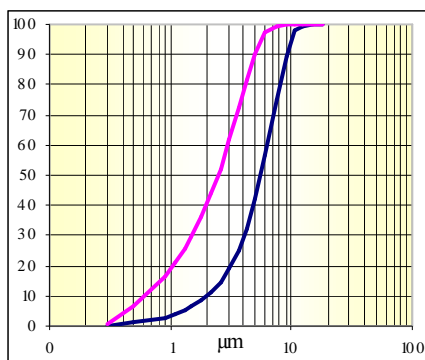


Fig. 1. Cumulative size distribution

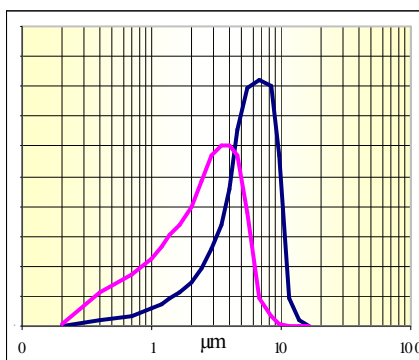


Fig. 2. Distribution

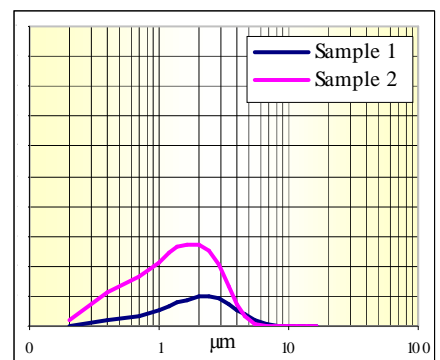


Fig. 3. SWeRF

Size Weighted Respirable Fraction (SWeRF)

Although both samples have the same amount of particles in the 0 – 16 μm size range, it is clear that sample 2 is potentially more dangerous. It contains more fine particles with more chance to enter deep into the lungs when inhaled. Particles with an aerodynamic diameter of e.g. 1 and 10 μm are both considered being respirable. The difference is that the particle of 1 μm has, according to European standard EN 481, a probability of 97.1 % of reaching the alveoli, as compared to only 1.3 % for the particle of 10 μm .

By applying a greater weighting to the finer particles, it is possible to express the difference in potential health hazard. The SWeRF of a particulate material is calculated by combining the amount of particles of a certain size, with their probability of reaching the alveoli when inhaled.

The fraction of particles of 1 μm is multiplied by 97.1 % and the fraction of particles of 10 μm is multiplied by 1.3 %. After doing this for all size fractions (see fig.3), this adds up to a SWeRF of 16.4 % for sample 1 and 50.7 % for sample 2. This indicates that, when inhaled under the same conditions, three times more dust of sample 2 would reach deep into the lungs as compared to sample 1.

Size Weighted Respirable Fraction for Crystalline silica (SWeRF_{CS})

Methodology/ implementation

After determination of the SWeRF of a material it is possible to determine the SWeRF_{CS}, using the SWeRF result. The only additional information you need to have or to determine is the quantity of CS that is present in the material (bulk or sediment fraction i.e. the suspended fines), and multiply this result with the SWeRF result.

There are two ways to determine the SWeRF and SWeRF_{CS}:

1. the calculation method through a simple Excel sheet,
2. the sedimentation method in a liquid.

Experiments have been done on quartz sand and flours, feldspar, limestone, leucophyllite, clay and diatomaceous earth and it has been shown that:

- For quartz flours and sand, the calculation method can be applied directly and provides an accurate result which is consistent with the sedimentation method.
- For some minerals the calculation method may provide an overestimation of the SWeRF_{CS}, in which case the sedimentation method will give a more accurate figure. This is the case when the PSD (Particle Size Distribution) of the CS in the material is significantly coarser than the PSD of the bulk material.
- For the sedimentation method, more investigation is needed, for some minerals, to find a suitable liquid and/or dispersant agent.

As a result, the IMA Metrology WG considers that the SWeRF and SWeRF_{CS} are valid methods - provided the necessary experiments and adjustments are made for each mineral. The IMA Metrology WG recommends standardisation of the method through CEN.

Relation to occupational exposure

Concentration of respirable particles in the air during processing depends on two factors

1. SWeRF or SWeRF_{CS} of the product
2. Handling of the product.

This means that SWeRF can not be used to calculate occupational exposure levels of dust because

- the handling and environment at the workplaces are unknown
- in reality, it is unlikely that all particles within the respirable size range will be deagglomerated and become airborne.

The advantage of SWeRF or SWeRF_{CS} is that products can be evaluated independently of their handling.

Conclusion

The SWeRF and SWeRF_{CS} should be used to indicate the potential health hazard of a particulate material because it takes into account both size distribution and amount of the fine particles in the bulk material. The fraction of fine particles alone is insufficient.

The SWeRF and SWeRF_{CS} of a product are single numbers, which makes them ideal for comparing different materials in terms of their potential health hazard and possibly for classification and labelling.

Current situation

The SWeRF and SWeRF_{CS} methodology will be submitted to CEN for standardisation through a faster procedure (PQ procedure) in the next two months. In the meantime, all IMA sections are working on a methodology specific for their mineral(s).

References

- European Standard EN 481: Workplace atmospheres – Size fraction definitions for measurement of airborne particles.
- Determination of the Size weighted respirable fraction of crystalline silica in bulk products, Ingeborg Pensis (Ankerpoort), Joyce Mareels.(working paper).
- SWeRF_{CS}, Size Weighted Respirable Fraction of Crystalline Silica A method for evaluating respirable crystalline silica content and related hazard potential in bulk materials, Ingeborg Pensis (working paper).

