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Nanomaterials — Quantification of nano-object release from powders by generation of aerosols

Nanomatériaux — Quantification de la libération de nano-objets par les poudres par production d'aérosols

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Foreword

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ISO/TS 12025 was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*.

Introduction

The emissions or release of nano-objects into the surrounding air from powdered nanostructured materials resulting from handling is an important consideration in the design and operation of many industrial processes. Released nano-objects may affect human health and the environment, depending on the nature and quanitity of the nanomaterial. It is therefore important to obtain data about the propensity of nanomaterials to release nano-objects, thereby allowing exposure to be evaluated, controlled and minimised.

Three main target groups of experts for the evaluation of the release of nano-objects from powdered nanostructured materials are:

— material scientists and engineers, who design safe nanomaterials and safe nanomaterial handling processes;

— occupational, health and safety specialists;

— environmental specialists, who need exposure data in addition to toxicity data for risk assessment of manufactured nanomaterials (see A.2) and who collect dustiness data (gravimetric as well as particle concentration and particle size information).

The propensity of nanomaterials to release nano-objects into the air is determined by test methods devised to apply energy to a sample to stress the intra-particle bonds. This stressing induces abrasion, erosion or comminution, which causes dissemination of the particles into the gaseous phase, i.e. generation of aerosols allowing quantification with aerosol instrumentation.

Methods to measure the release of nano-objects from nanomaterials may include dustiness testing methods but basic differences from conventional dustiness methods should be considered. The high variability of the flow properties of powders and the influence of the test setup should also be considered. Conventional dustiness methods for micrometre size particles estimate the amount of dust generated in terms of dust mass fraction or dustiness indices. The methods of aerosol generation for the determination of the dustiness of powders containing primary particles of less than 10 µm in diameter have been found to produce very dissimilar results.

There are a large number of possible combinations of different approaches for the design of dustiness methods[1]. The only current standard, EN 15051:2006[2], selected two methods: the rotating drum method and continuous drop method. The measured values are the inhalable, thoracic or respirable mass fractions, expressed in mg/kg.

Definitions of the inhalable, thoracic and respirable fractions can be found in EN 481[3]. Aerodynamic diameters of 100 µm, 10 µm and 4 µm are the upper limits of the corresponding size fractions. These mass fractions, which are relevant for inhalation, can be added as measurands in measurement of aerosolised nano-objects to characterize the complete particle release scenario.

Schneider and Jensen[4] described approaches using particle size distributions by number to relate exposure from nano-objects in the indoor environment to source strengths resulting from the release of nano-objects during the handling of nanostructured powders. They concluded that dustiness testing combined with online size distribution measurements provides insight into the state of agglomeration of particles released during handling of bulk powder materials.

Furthermore, the evaluation of the release of nano-objects from powdered nanostructured materials requires additional methods and measurands compared to the methods assessing the dustiness of powders. Particle number concentration and size distribution are other measurands necessary for quantifying the release of nano-objects.

Aerosols of nano-objects are more dynamic than micrometre sized particles because of greater sensitivity to physical effects such as Brownian diffusion. Porosity and cohesion of the powder can be much higher than those containing larger particles with more resistance to flow and lower volume-specific surface area. Nano-objects in powdered materials can dominate relevant properties of the bulk material by particle-particle interactions that form clusters like agglomerates. There is still a lack of understanding in the characterization of these secondary nanostructured particles, consisting of primary nano-objects. It has been shown for fumed silica, as an example, that the resulting aerosol particle size distribution depends strongly upon the conditions involved in the different measuring methods[5][6].

Aerosols and powders are also generated by tribological abrasive tests[7] of nano-composites and paints containing nanoparticles[8][9]. Such abrasion tests are not addressed by this Technical Specification. However, the measurement methodology of these publications has been proven for the quantification of nano-object release from wear powders by generation of aerosols.