*Ann. Occup. Hyg.*, Vol. 50, No. 5, pp. 437–439, 2006

Published by Oxford University Press
doi:10.1093/annhyg/mel042

Commentary

# Dustiness Testing of Materials Handled at Workplaces

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Received 21 December 2005; in final form 16 March 2006

Occupational hygiene for airborne chemicals and other materials has mainly focused on the world as it is rather than how it might be changed. We have described as scientifically as possible workers' exposure and its determinants, and the effectiveness of control equipment and control strategies. This has led to a long string of good tools such as occupational exposure limits, sampling strategies and devices, check-lists, product information sheets, communication to employers and employed, and more cost-effective control equipment. All these tools have been continuously sharpened, and we have seen a very significant lowering of the exposure in the past 30–40 years.

But we have looked much less at the production processes and the ways that materials are handled, and how these affect exposure. It is easy to say why. Production management is usually unwilling to let us make experimental changes with a process, so we must use good model experiments.

One area that has been studied is dustiness testing of powdered, granular or pelletized materials. Dustiness, defined as *the propensity of a material to generate airborne dust during its handling*, can be tested by standardized techniques that involve applying a specified type and amount of mechanical energy to a specified amount of test material for a specified time in order to overcome adhesive binding forces within the test material (Plinke *et al.*, 1992), and thus disperse/release existing particles from the test material into the air. The amount of dust released is then determined.

One major problem, however, is that dustiness is not a well-defined physical or chemical property of a material. The particle size distribution, humidity and the nature of the adhesive forces binding the particles of the test material together are important for the dustiness. The material is conceived as consisting of agglomerates of varying strengths, which in turn are made up of primary particles. The intention behind dustiness testing is that the energy applied should not be enough to divide the primary particles, e.g. by grinding, cutting and crushing, only to a varying degree separate primary particles from other primary particles and agglomerates, and also agglomerates from the bulk material. A higher input of energy or power will overcome stronger binding forces, and thus the measured dustiness will be higher. The method for applying the mechanical energy is also important. The outcome is that the measured dustiness depends on the test method: for some materials the differences can be substantial and different test methods may not even rank materials of widely differing dustiness values in the same order. But the different tests may simulate different work situations, which means that there may be no single 'right' test. The result is that a number of test apparatuses and corresponding test protocols have been developed either for general use or within a certain technical application/industry. These methods may constitute formal or informal standards.

So this conceptually simple problem turns out to be something of a morass. A BOHS Working Group discussed and experimented for over a decade. It described many methods, stretching back to before the Second World War (BOHS, 1985), but in the end did not reach its goal of a standard method. Partly in response to this failure, HSE produced an MDHS on the rotating drum method (Chung and Burdett, 1994; HSE, 1996), although this does not meet all needs.

It must be remembered that dustiness values, stated as the ratio of the weight of the amount of released

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dust to the amount of material charged, generally are very low. In most cases dustiness is much lower than 1%, but for extreme materials this value may exceed. From the point of view of material loss, dustiness may not be a significant problem, but this is not true from an occupational hygiene point of view.

The ideal would be of course to be able to use dustiness as a predictor of worker exposure. For this, three aspects are important. (i) It is necessary to sample the emitted dust according to the biologically relevant aerosol sampling conventions, the inhalable, thoracic and respirable aerosol fractions. (ii) The test procedure and especially the method for applying the mechanical energy must be relevant for the intended handling of the material at workplaces. (This could be checked by comparing the ranking order of the dustiness of materials obtained using a test method with that obtained when the same materials are handled at workplaces or simulated workplace operations.) This implies that different dustiness test methods may need to be employed depending on how the material will be handled at workplaces. (iii) A conversion factor between measured values of dustiness and dust source generation strength at workplaces (or possibly as a surrogate, workers' exposure) for some standardized work operations need to be derived. This might lead to determination of a 'health-related insignificant' dustiness, corresponding to an occupational exposure limit.

Various attempts have been made to relate dustiness test results to worker exposure. A NIOSH team tried this many years ago at four workplaces with bag filling and dumping operations, but the success was very limited (Heitbrink *et al*, 1990), possibly because they could not control such factors as work practices, equipment maintenance, process leakage, dust transport from other work stations. Breum *et al.* (2003) compared exposures for various insulation materials during standardized tasks, and tried to relate these to dustiness measured using a rotating drum. There was a clear positive correlation with exposure, but the authors did not try to use the results for prediction. Also with insulation materials (refractory ceramic fibres and calcium magnesium silicate wools), Class *et al.* (2001) compared dustiness measured by a shaking box with workplace results, and found that both types of fibres had quantitatively similar dustiness values and for five different work operations caused very similar fibre concentrations.. In this issue, Brouwer *et al.* (2006) relate rotating drum results to exposure during specifically designed sweeping/cleaning and scooping/weighing/adding operations in a ventilated laboratory room, and find that the tests explained ~70% of the exposure variances, and also gave some information on the respirable/inhalable ratios.

The limited success of this sort of work illustrates that dustiness measurements are never going to be complete predictors of worker exposure, but at best the source strength of dust generation of the intended process. At each workplace, equally important parameters will be the strategy and technology of dust control, and how the material is actually handled. Hence, limits on dustiness cannot take over the role that occupational exposure limits have in occupational hygiene and medicine.

Nevertheless, determining the source strength would be an important step forward. It could be used with models such as EASE to estimate likely exposure, and in this case the developers recognized the lack of a measure of 'intrinsic dustiness' which they could use as an analogue of liquid volatility (Tickner *et al.*, 2005). Even in the absence of a standard method different teams have continued to use dustiness as a measure of source strength. Recently, Madsen *et al.* (2004) examined biofuels, used a rotating drum to investigate various aspects of microbe release, and have now investigated details of particulate release with a view to relating the results to workplace risk assessment (Madsen *et al.*, 2006). Tackling a very different problem, also in this issue Boundy *et al.* (2006) have looked at dustiness of pharmaceuticals during product development, which required development of a new test to deal with the special problem of the small quantities available.

Therefore I expect that the importance of dustiness testing in the area of occupational hygiene will be mainly for producers/suppliers wishing to modify their powdered, granular or pelletized products in order to minimize their dust generating capacities. Possibly this might lead to customers specifying dustiness as one additional item on their list of specifications for product procurement. On the other hand, here I expect that dustiness testing will be of great help in our objective to reduce the exposures to dust at workplaces.

The European Committee for Standardization (CEN) issued a European standard on dustiness testing in relation to workplace exposure (EN 15051) in April 2006. The standard describes two methods that are based on a British method (MDHS 81) and a presently withdrawn German method (DIN 33897:2), respectively. The two methods represent different systems for supplying the mechanical energy. The British method is based on a rotating drum whereas the German method is based on material falling in a steady stream once only against a counterflow onto a small heap. It will thus be possible for the user of the standard to select the method most resembling the intended use of the material. CEN hopes that the publication of this standard will stimulate the use of dustiness testing as a means to reduce workers' exposure to dust.

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