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JobHealth Highlights

Technical Information for Occupational Health and Safety Professionals

Engineered Nanoparticles and Particulate Respirators

One of the emerging topics in industrial hygiene today is nanotechnology and engineered nanoparticles. This article will discuss how particulate respirators filter engineered nanoparticles and other small particles, such as viruses.

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Introduction

Engineered nanoparticles generally refer to structures approximately 1-100 nanometer (nm) in size, that have novel properties and functions because of their nanometer scale dimensions. It should be noted that particles in this size range are also unintentionally produced by certain industrial processes (e.g. welding) or combustion and occur naturally in the atmosphere.

At this time there are no published exposure limits for engineered nanoparticles. More research needs to be done to determine the best way to measure worker exposure, and what specific health effects may result, if any, from exposure.

According to industrial hygiene principles, a hierarchy of control measures may be used to help reduce worker exposure to hazardous levels of contaminants to safe levels. These include enclosing the process, local exhaust ventilation, and personal protective equipment (PPE) such as particulate respirators.

Particulate Filtration

The question has arisen as to whether particulate respirators can filter very small particles such as nanoparticles or viruses. To answer this question, one must first understand particle filtration mechanisms.

Particulate filters used in respirators do not work like sieves. Particles may be much smaller than the spaces between fibers in the filter. However, particles need to pass through multiple layers of fibers to get through the filter. Larger particles may impact or be intercepted by the fibers as they move through the filter. Particles in the 1-100 nm range collide with air molecules and are thus forced to move in a random motion called Brownian diffusion. This diffusive motion may cause particles to contact a fiber in the filter. Once the particle has made contact with a fiber, it will adhere to the filter fiber due to Van der Waals forces. Many current respirators also use electrostatically charged fibers to increase the "capture" capability or filtration efficiency.

Filtration efficiency will depend on several factors, including the filter, particle size, flow rate, measurement device, etc. Figure 1 shows test results from six different models of N95 filtering facepiece respirators that were commercially available from various manufacturers in 2006. Filtration efficiency was measured at seven different particle sizes using a sodium chloride (NaCl) aerosol at a flow rate of 85 liters per minute. Ten samples of each respirator model were tested.

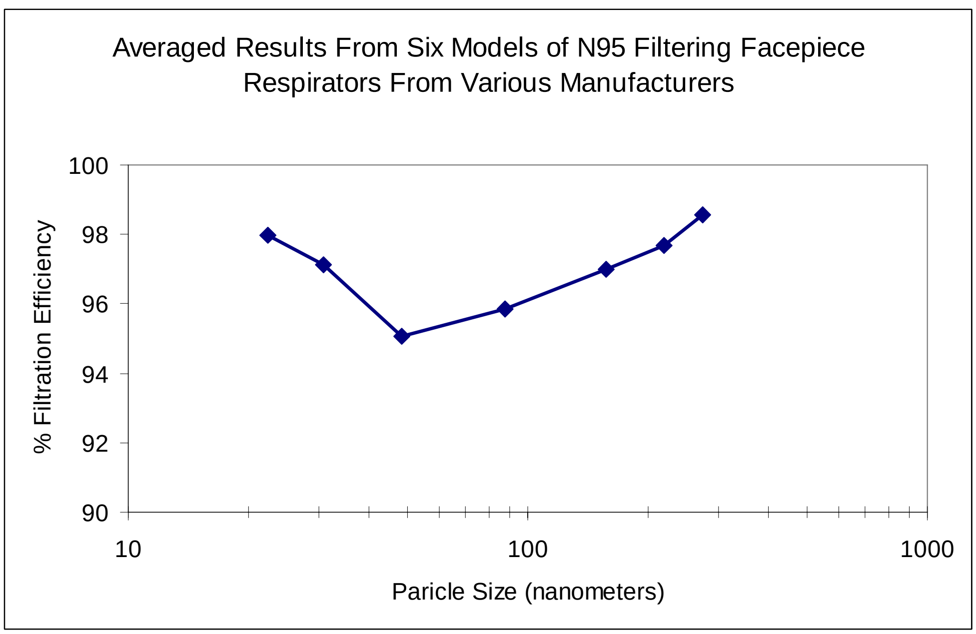

Figure 1

Engineered nanoparticles can be filtered by NIOSH approved particulate respirators

Filtration efficiency varied between models and within the ten samples of each model. However, the shape of the filtration efficiency curve was similar for all tests, with the most penetrating particle size (MPPS) falling in the range between 40 and 100 nm. Figure 1 clearly illustrates that "smaller" particles are not necessarily more difficult to capture due to diffusion and electrostatic attraction. Thus, engineered nanoparticles can be filtered by NIOSH approved particulate respirators.

It should be noted that the National Institute for Occupational Safety and Health (NIOSH) tests particulate respirators with an aerosol that contains a range of different sized particles. For the "N type" respirators, the median size of the test particle, by count, is 75 nm. For R and P type respirators, the median size of the test particle, by count, is 185 nm. The automated filter test used by NIOSH (TSI 8130) gives a single measurement of filtration efficiency for the entire aerosol as opposed to filtration efficiency according to particle size as shown in figure 1. Thus, the two methods may give slightly different results. However, they both may be used to assess respirator performance against nanoparticles.

Facial Fit

Some individuals have speculated that face fit of the respirator is even more critical when nanoparticles are present because of their small size. However, the fit test methods in use today have been widely used to fit respirators for use against gases and vapors which are even smaller than nanoparticles. Respirators are commonly used against gases and vapors in industrial applications. Therefore, these same fit test methods are applicable for respirators used during exposure to engineered nanoparticles.

For those who would like to perform fit testing using nanoparticles, particulate respirators may also be fit tested using the TSI PORTACOUNT® Pro+ Fit Tester. This device measures fit according to particles in the air that are roughly 40 nanometers in size.

Conclusion

Particulate respirators may be used to help reduce exposure to engineered nanoparticles, but do not completely eliminate exposure or potential risk of illness. Respirators must be used in conjunction with a respiratory protection program that complies with the OSHA standard for respiratory protection 29 CFR 1910.134. This includes, but is not limited to fit testing, medical evaluation, training on proper use and limitations, maintenance, wearing the respirator during all times of exposure, etc. Exposure reduction may be estimated using the assigned protection factor (APF), not filtration efficiency. A list of APFs is given according to respirator type in the OSHA standard.

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