Effectiveness of local exhaust ventilation in removing nanoparticles in workplaces

Frijns, E.[2], Peters, J.[2], Domat, M.[1], Fito, C.[1]; Berghmans, P[2]

[1] ITENE, C/ Albert Einstein, 1, 46980 Paterna (Valencia), SPAIN
[2] VITO NV, Boeretang 200, BE-2400 Mol, BELGIUM
Presenting author email: jan.peters@vito.be

Local Exhaust Ventilation (LEV) is an Engineering Control (EC) that is one of the primary methods to reduce employee exposure to airborne contaminants (dust, mist, fume, vapour, gas or Engineered Nanomaterials, ENMs) in the workplace. The emission at the source is captured and carried away to a safe emission point or to a filter/scrubber.
Its efficiency has been widely studied against different contaminants. However, due to the increased use of nanomaterials in the industry, its efficiency against particles below 100 nm must be validated. Nanoparticles and ENMs move faster than larger particles, and its movement is not only due to external factors such as the flow rate, but other forces modify their path, such as Brownian motion or electrostatic forces. Thus, the characteristics to efficiently capture micron-sized particles might not be applicable to ENMs.

An in-depth study of the LEV efficiency in removing ENMs was performed both in laboratory and at industrial locations. A set of Standard Operating Protocols (SOPs) were developed for ENMs efficiency and containment testing of the LEVs. In the first place efficiency testing was performed in the laboratory using the developed SOPs. In the second place industrial activities handling ENMs were simulated in the lab with and without the use of LEV. In the third place nanoparticle exposure was measured before and after the implementation of LEVs at two industrial facilities.

The efficiency of a capture hood was determined using 50 nm NaCl generated nanoparticles inserted through diffuser pipes in a particle free test chamber (figure 1). With a tilted hood LEV effectiveness decreased as a function of distance to the source. With a hood positioned on top significant disturbances were noticed above the working area.

Figure 1. Diffuser pipes with capture hood inside particle free test chamber

A partial enclosure was tested using a customized version of standard EN 14175-3. The SF_6 was replaced with 50 nm NaCl nanoparticles and the partial enclosure was positioned in a particle free test chamber. Simultaneous injection of NaCl and measurement of particle number concentration in a sampling grid (9 CPCs) was performed at six positions inside the partial enclosure. The average efficiency was 99%, however efficiency strongly depended on the position inside the enclosure.

Sieving of nano SiO_2 was simulated inside the particle free test chamber with and without LEV. A reduction in particle number concentration of 74% was achieved as well as a reduction in mass concentration of 88%.

Nanoparticle exposure was measured before and after the implementation of LEVs at two industrial processes:

1. Extrusion with Thermo-plastic Elastomer (TPE) and nanoGraphene (figure 2)
2. Weighing and bagging of nanoGraphene

Figure 2. Extrusion line with ventilation on top

The release of Graphene nanoparticles was reduced up to 46%. A good ventilation design to maximize performance and proper positioning of the capture hood are crucial.

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EN 14175-3:2003 Fume cupboards. Type test methods