EFFECTIVENESS OF LOCAL EXHAUST VENTILATION IN REMOVING NANOPARTICLES IN WORKPLACES

HEALTH

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BACKGROUND

Priority of control measures

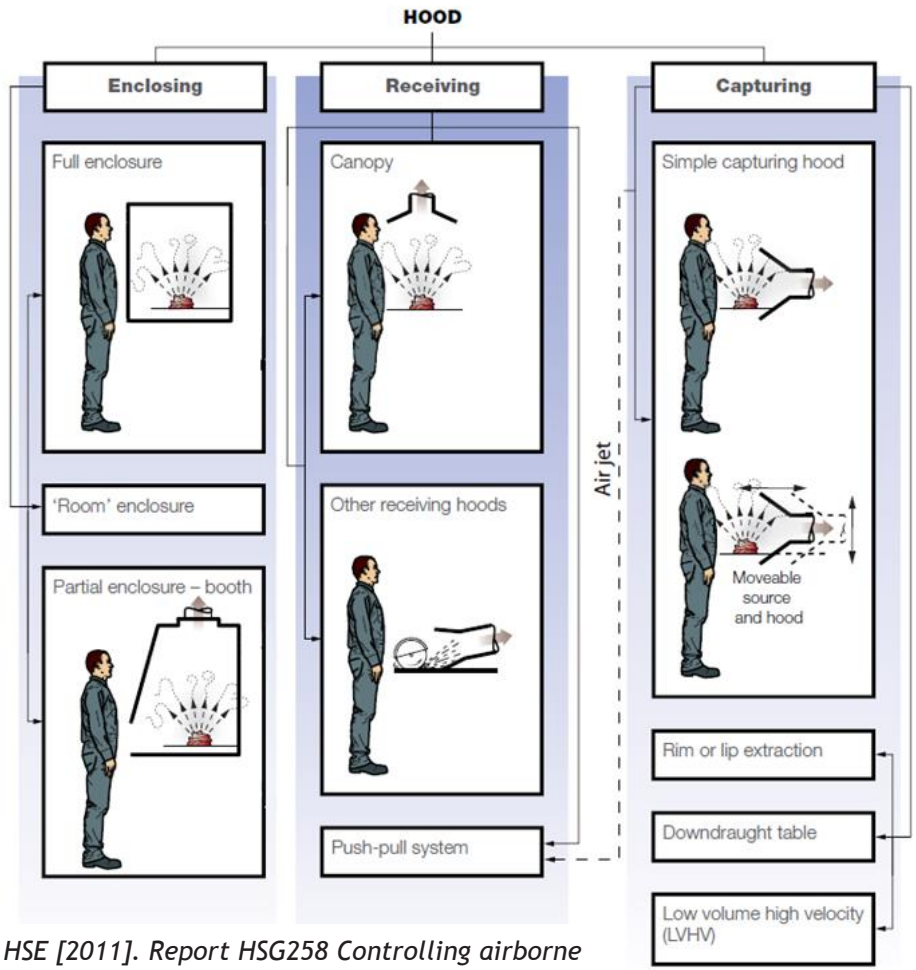
1. Eliminate product and use safer one
2. Use a safer form
3. Change the process
4. Enclose the process
5. Extract emissions
6. Expose as few workers as possible
7. Provide PPE

Local Exhaust Ventilation (LEV)

» Engineering Control (EC)

» Reduce worker exposure to airborne contaminants (dust, mist, fume, vapour, or ENMs)

» Emission is captured and carried away to a safe emission point or to a filter/scrubber.



HSE [2011]. Report HSG258 Controlling airborne contaminants at work - A guide to local exhaust ventilation (LEV)

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AIM

Increased use of nanomaterials in the industry.

LEV efficiency against particles below 100 nm must be validated.

- NPs move faster than larger particles;
- NP movement is not only due to external factors (flow rate), but also due to e.g. Brownian motion or electrostatic forces.

Efficiency testing of LEVs was performed:

1. In the laboratory using specifically developed **SOPs**.
2. In the laboratory **simulating industrial activities** handling ENMs with and without the use of LEV.
3. At two industrial facilities **after the implementation of LEV** (LEV switched on/off).

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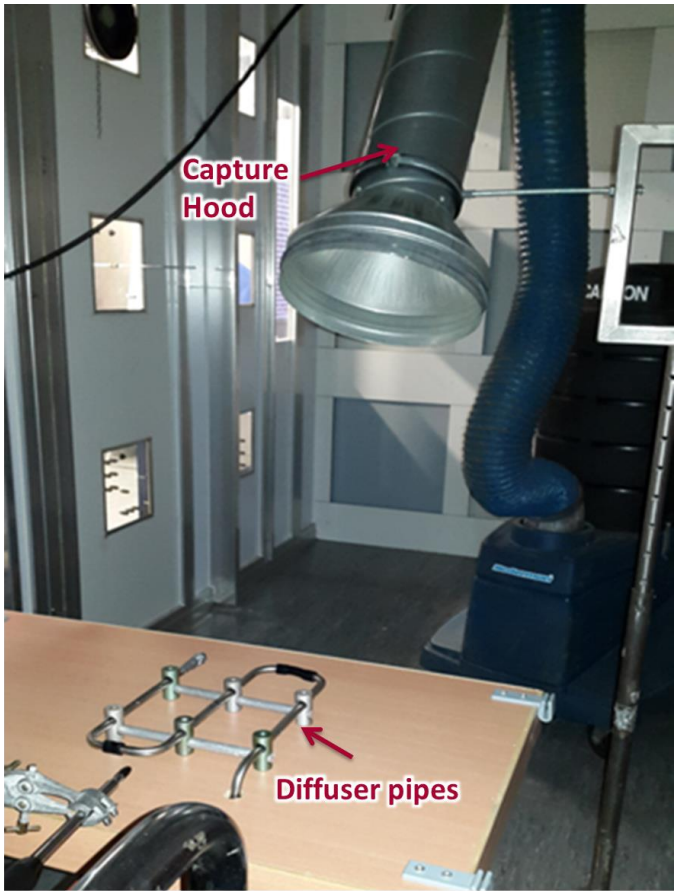
1A EFFICIENCY TESTING CAPTURE HOOD

Capture Hood

- SOP development based on Ellenbecker et al (1983) *Capture efficiency of LEV*
- Mobile capture hood (HEPA >99,97%) extended with straight duct (Ø30cm) to obtain homogeneous flow conditions in measurement plane
- Inside particle free test chamber (36 m^3)
- Diffuser pipes
- 6-jet atomizer / 50 nm NaCl
- Measurements inside duct and surrounding area with CPC
- Total PNC at 100% aerosol capture (capture hood covering diffuser pipes) compared with total PNC at different capture hood-diffuser distances
- Tilted/perpendicular



Diffuser pipes with tilted capture hood inside particle free test chamber

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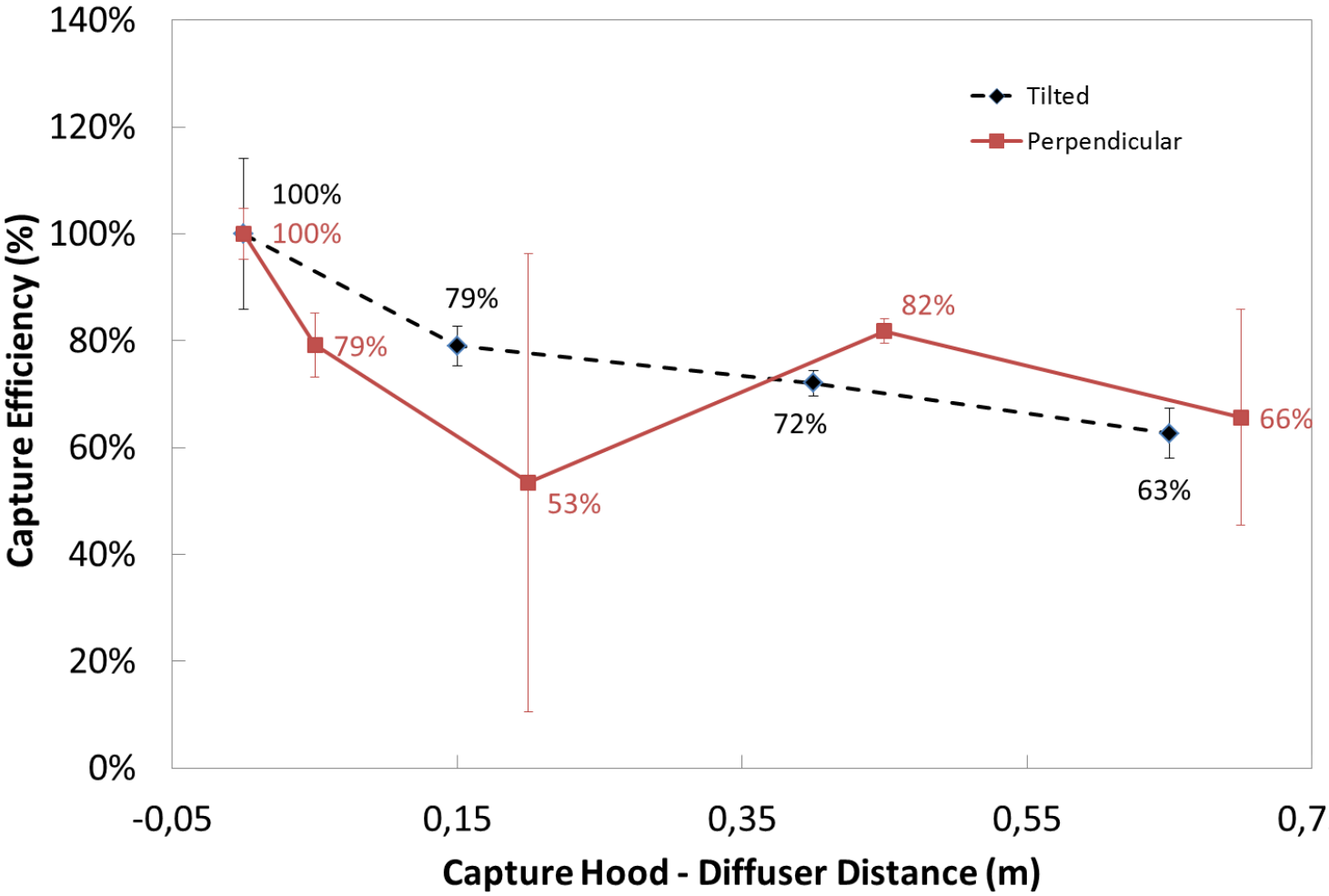
1A EFFICIENCY TESTING CAPTURE HOOD



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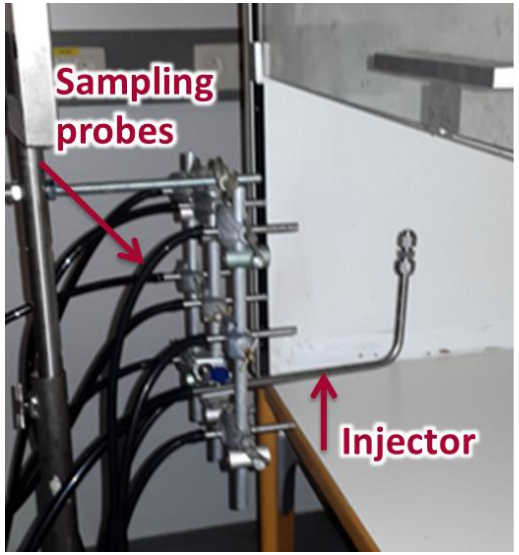
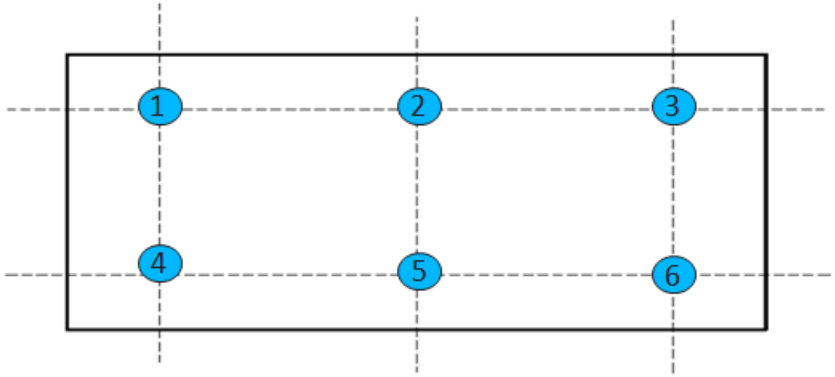
1B EFFICIENCY TESTING PARTIAL ENCLOSURE





Partial enclosure

- SOP development based on EN 14175-3 Fume cupboards - Part 3: Type test methods (with SF6).
- Fume cupboard inside particle free test chamber (36 m^3)
- Sash 45 cm
- Test gas injector (punctured hollow stainless steel cylinder)
- 6-jet atomizer / 50 nm NaCl
- SS sampling grid connected to 9 individual CPCs
- Six measurement positions inside the fume cupboard at intersections of two horizontal and two vertical lines

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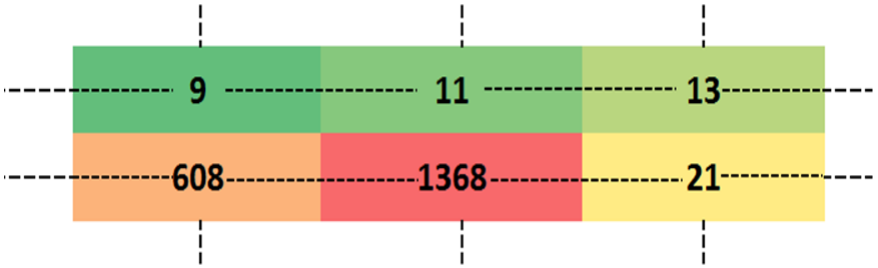
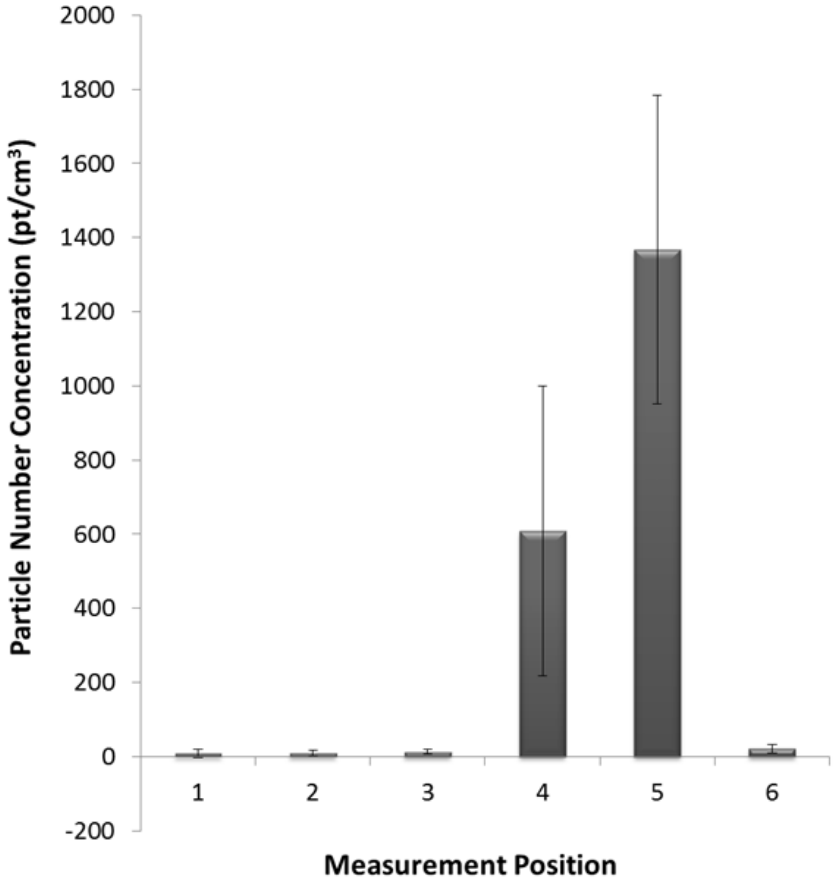
1B EFFICIENCY TESTING PARTIAL ENCLOSURE

Average PNC in pt/cm^3 (N=3) at six positions inside fume cupboard





Total average efficiency 99.04 ± 0.36 %

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2 EFFICIENCY TESTING SIMULATING INDUSTRIAL ACTIVITY

Sieving

- Vibrating sieve inside particle free test chamber
- White buckets filled with nano SiO_2 (20 nm)
- Emptied on vibrating sieve from outside with glove box gloves
- Repetition 3 times with / 3 times without LEV
- Measurement of nano (PNC) and micro sized (TDC) particles at three positions (upstream, above, downstream)

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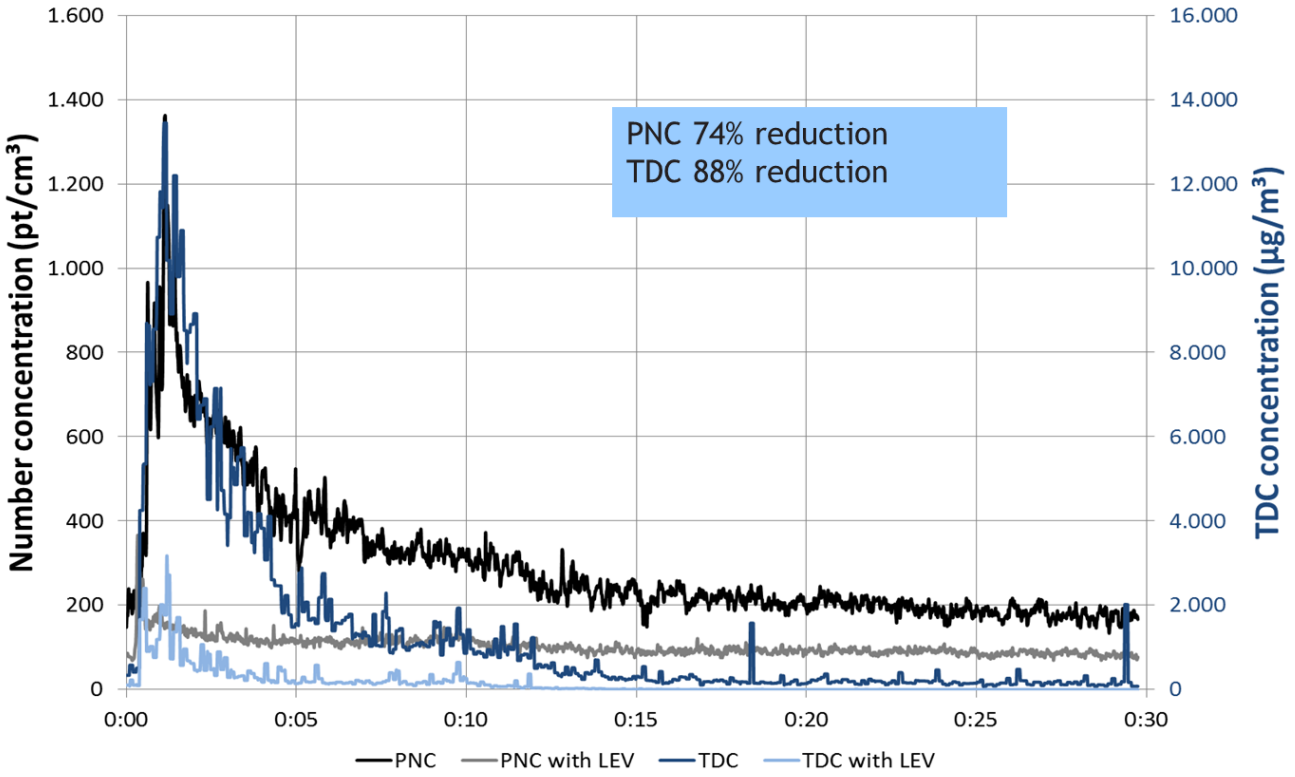

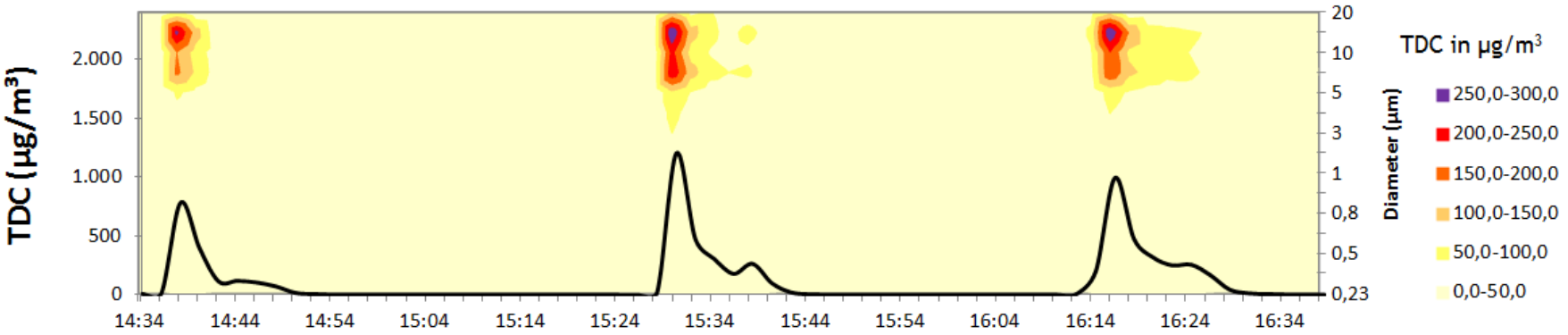

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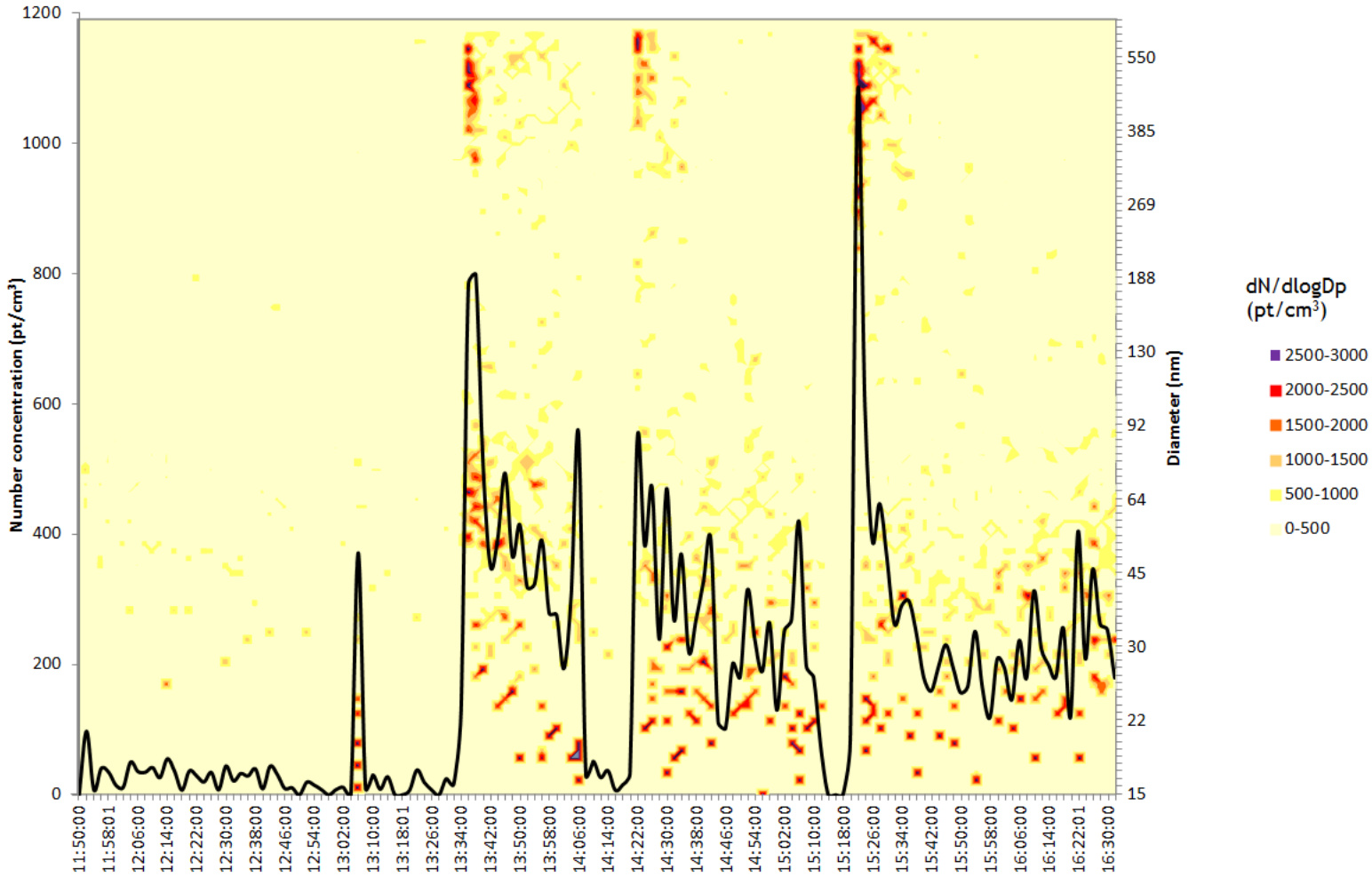
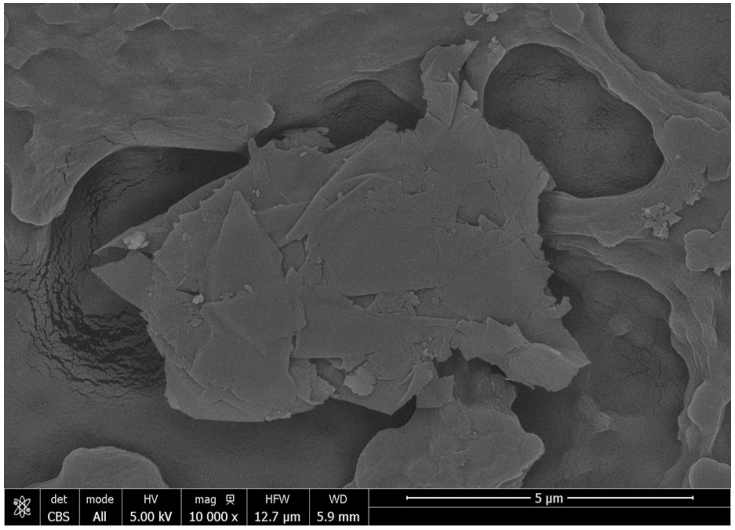
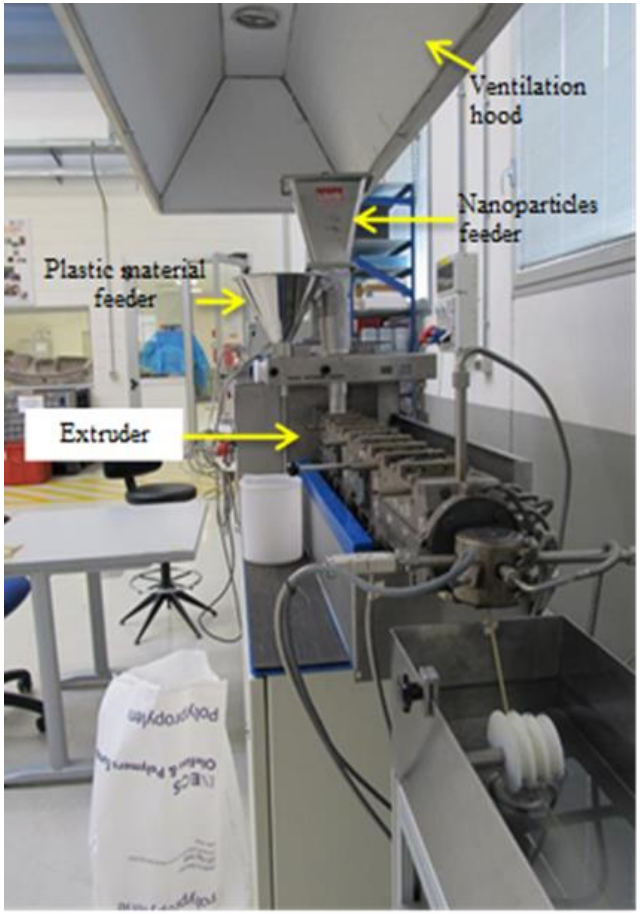


3A IMPLEMENTATION OF LEVS IN REAL CASE SCENARIO 1

Extrusion with Thermo-Plastic Elastomer (TPE) and nanoGraphene

- Weigh + filling NP hopper inside fume cupboard
- Pellets fed and heated
- Stable
- Feed NanoGraphene (10 nm)
- Cleaning extruder with PP





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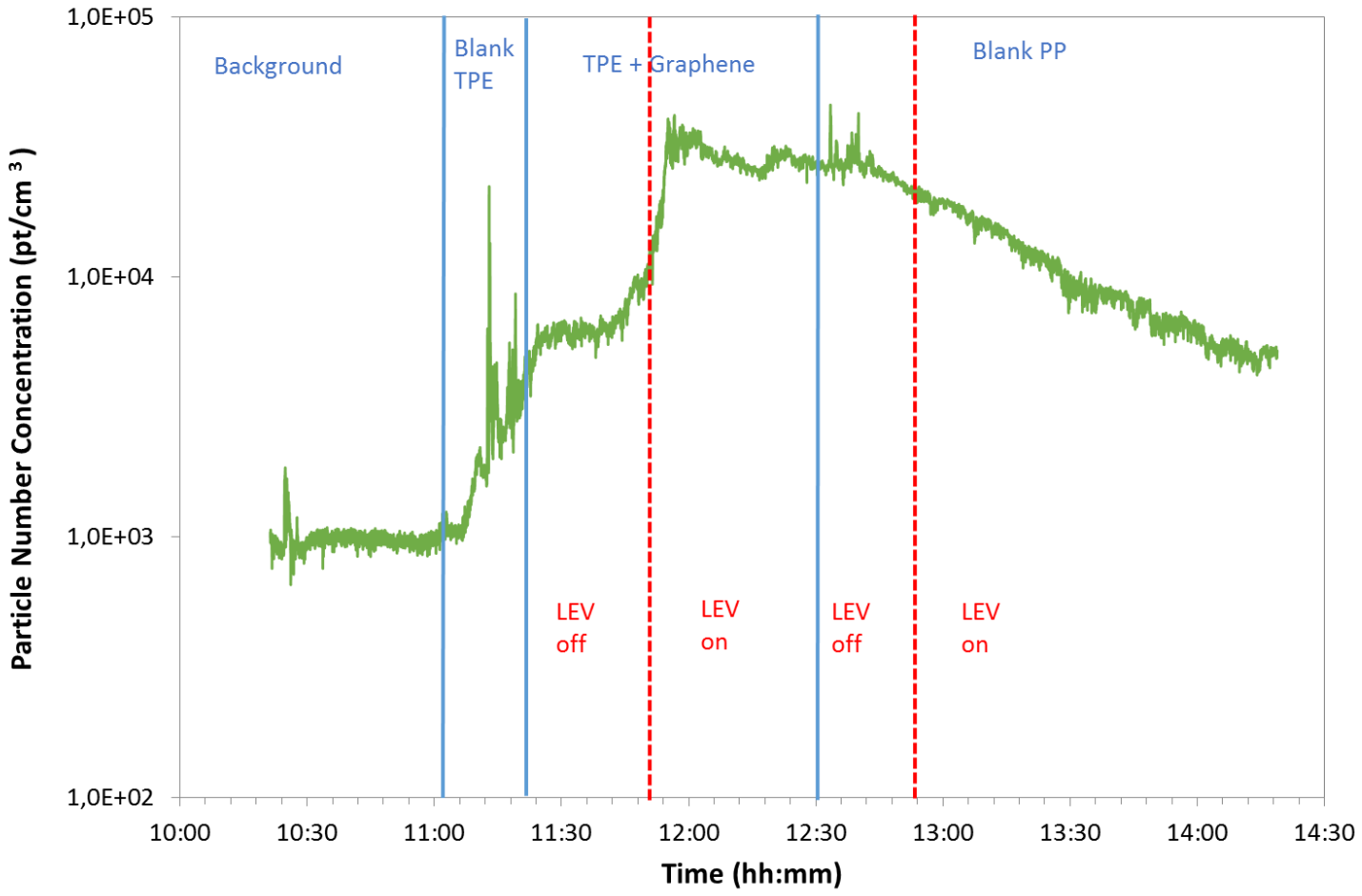

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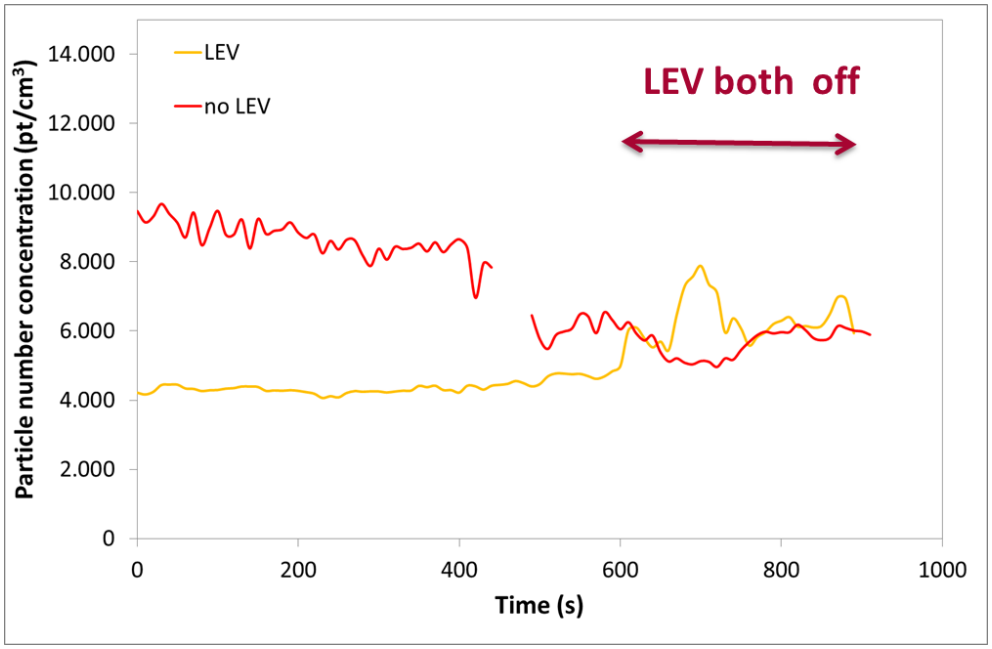
3B IMPLEMENTATION OF LEVS IN REAL CASE SCENARIO 2

Weighing and bagging of nanoGraphene



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SUMMARY/CONCLUSIONS/RECOMMENDATIONS

Efficiency testing partial enclosure and capture hood in lab

- Positioning capture hood perpendicular to work surface reduced efficiency
- Fume cupboard was not capable of containing 100% of the generated nanoparticles. To prevent any inhalation exposure (precautionary principle) a FP3 filter mask should be worn when working with nanoparticles inside the fume cupboard.

Simulation industrial activity

- Simulating sieving of nano SiO_2 showed a 74% reduction in particle number concentration and 88% reduction in mass concentration when using a mobile capture hood

Implementation of LEVs in real case scenarios

- LEV was not efficient in capturing NPs when TPE was extruded with nanoGraphene because hood turbulence caused dispersion of the nanoGraphene
- Release of nano Graphene was reduced up to 46% when using a LEV during bagging and weighing.

- Good ventilation design and proper positioning are crucial for their efficiency
- Further research is needed for different particles and other enclosures/hoods

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ACKNOWLEDGEMENTS

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NanoRisk partners

Posters S3.3 P4
Life NanoRisk: evaluation of the effectiveness of risk management measures against nanomaterials
By Carlos Fito - ITENE

QUESTIONS? COMMENTS?

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