Effectiveness of Engineering controls (LEVs)

PACKAGING, TRANSPORT & LOGISTICS RESEARCH CENTER

ITENE

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Nuevos desarrollos en la evaluación y control de la exposición laboral a NMs: Experiencias en el marco del proyecto LIFE NanoRISK

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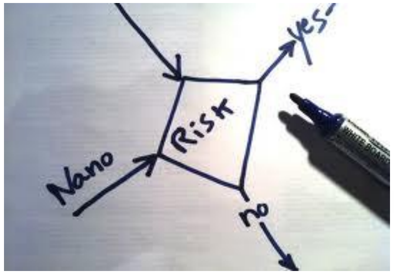
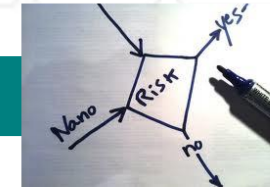
Índex

1. State of the Art regarding the effectiveness of LEVs
2. Testing activities and progress so far

1. State of the Art regarding the effectiveness of LEVs



1. State of the Art regarding the effectiveness of LEVs

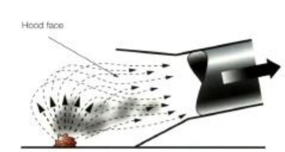


❑ Engineering control measures

Engineering control measures vary depending on the requirements of each workplace and it may be necessary for those working with ENPs to use a combination of methods to control exposure.

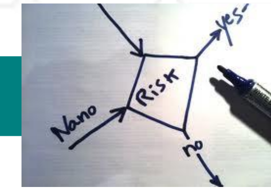
Total **enclosure or partial enclosures such as fume cupboards will be reasonably practicable for many operations with ENPs**, including manufacture/synthesis and weighing.

For cutting, sawing or polishing, simpler extracted enclosures and other LEV devices such as capturing/receiving hoods or down-draught benches may be appropriate. Particulate airborne materials have also been shown to be captured by electrostatic collectors



However, certain work activities may lead to higher potential exposure and therefore additional control measures may be necessary.

Effectiveness of Engineering controls (LEVs)

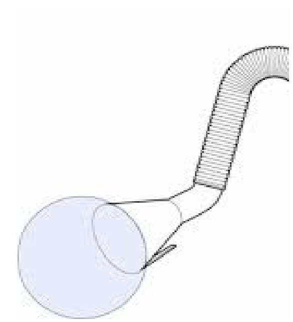


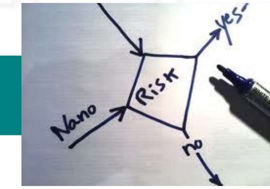
1. State of the Art regarding the effectiveness of LEVs

❑ Local Exhaust Ventilation (LEV

Local Exhaust Ventilation is an engineering control system to reduce exposures to airborne contaminants such as dust, mist, fume, vapour or gas in a workplace. **LEV systems are used to control emissions** from materials handling processes such as mixing, weighing and bagging. Most systems have the following parts

- Hood: This is where the contaminant cloud enters the LEV.
- Ducting: This conducts air and the contaminant from the hood to the discharge point.
- Air cleaner or arrestor: This filters or cleans the extracted air. Not all systems need air cleaning.
- Air mover: The ‘engine’ that powers the extraction system, usually a fan.
- Discharge: This releases the extracted air to a safe place





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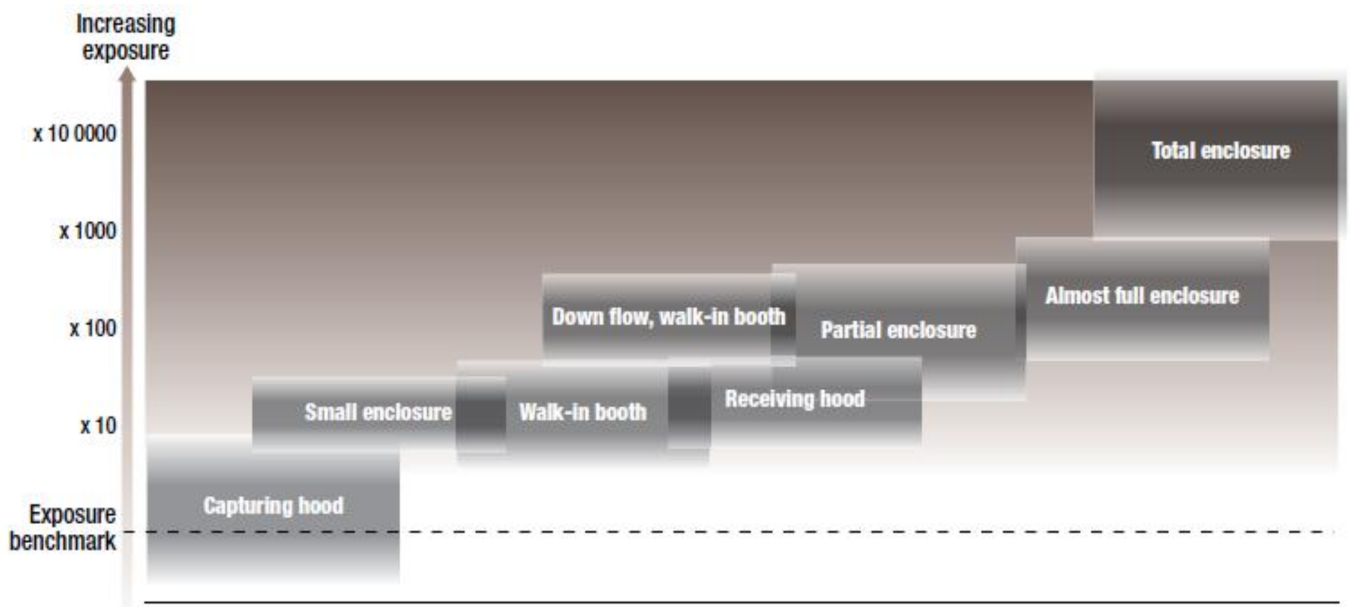
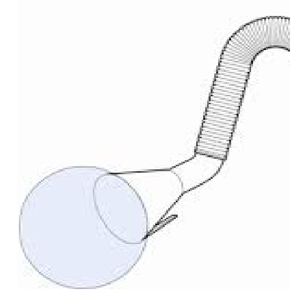
❑ Local Exhaust Ventilation (LEV)





Recommended containment systems on the basis on the levels of exposure, considering the use of a capturing hood for small levels of concentrations, and a total enclosure for high levels of exposure.

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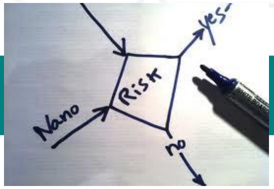
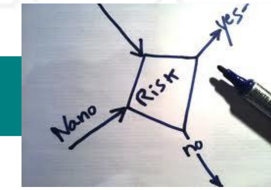


❑ Local Exhaust Ventilation (LEV)

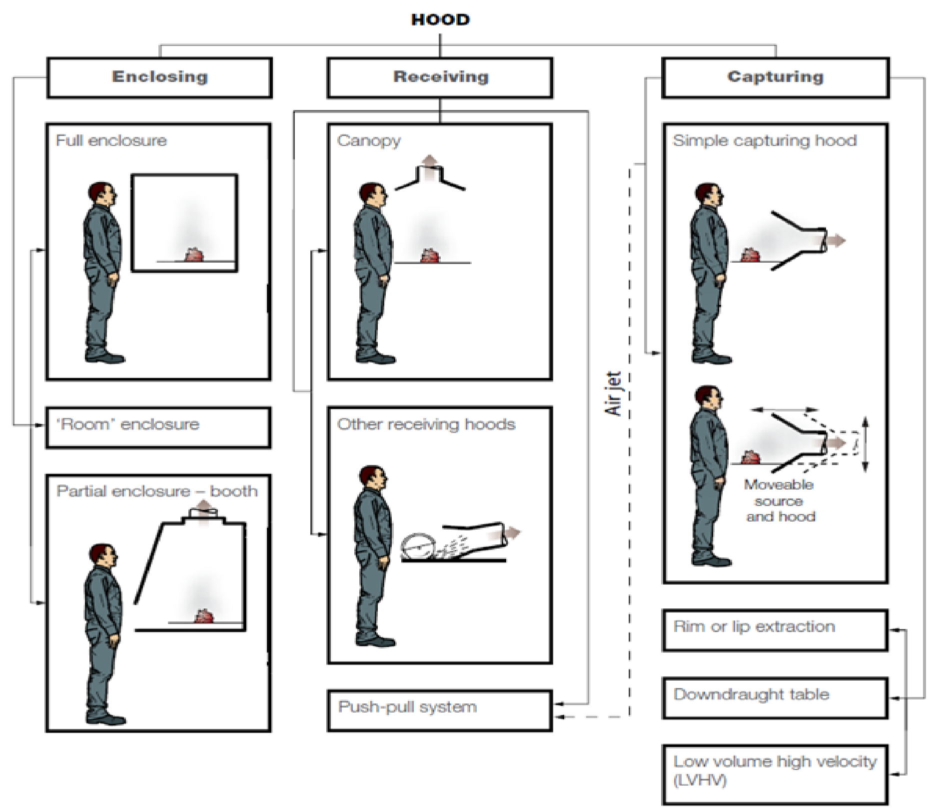
Category	RMM library Number	General Type	Specific Type	Performance Factor 1	Performance Factor 2	Performance Factor 3	Performance Factor 4	Performance Factor 5
Ventilation control	15	Local Exhaust Ventilation - (partial) enclosure	Ventilated tipping station - sack emptying	Concentration as function of extracted volume / Containment factor	Concentration as function of extracted volume / Robustness Containment factor	Exchange efficiency	Face velocity	Pressure drop
			Ventilated process enclosures					
			Fume cupboard					
			Laboratory hoods					
			Extracted booth/cabinet					
	16	Laminar Flow Booths & Laminar Flow Benches	Laminar flow booth					
			Laminar flow booth - Downdraft					
	17	Local Exhaust Ventilation - captor hoods	Local Exhaust Ventilation - with captor hood	Capture efficiency	Capture velocity at the canopy	Smoke capturing ability		
	18	Local Exhaust Ventilation - receptor hoods	Local Exhaust Ventilation - with receptor hood for dust					
			Local Exhaust Ventilation - with receptor hood for fumes/vapours					
			Integral extraction fitted to rotary-powered hand tool					
	19	Local Exhaust Ventilation - specialised applications	Local Exhaust Ventilation, push-pull system					



1. State of the Art regarding the effectiveness of LEVs

❑ Local Exhaust Ventilation (LEV

- ✓ To ensure the effectiveness of LEV systems, it is essential that the entry hood will be always positioned correctly and adequate capture velocity maintained. As in general ventilation, maintenance and cleaning of the systems may pose an additional risk of exposure.
- ✓ Hoods have a wide range of shapes, sizes and designs. They control contaminant clouds in three different ways according their classification:
  - Enclosing hood
  - Receiving hood.
  - Capturing hood



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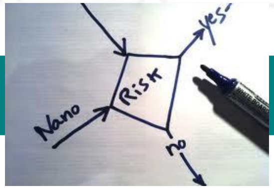

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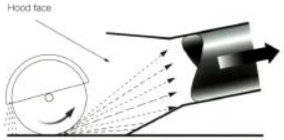
❑ Local Exhaust Ventilation (LEV)

Classification	Description	Assigned typical value	Guidance images
Local exhaust ventilation (LEV)			
- Receiving hoods			
Canopy hoods	A canopy hood placed over a hot process to receive the plume of contaminant-laden air given off. For cold processes with no thermal uplift, canopy hoods are ineffective.	0.5	
Other receiving hoods	**A receiving hood can be applied wherever a process produces a contaminant cloud with a strong and predictable direction (e.g. a grinding wheel). The contaminant cloud is propelled into the hood by process-induced air movement. The face of the hood must be big enough to receive the contaminant cloud and the extraction empties the hood of contaminated air at least as fast as it is filled.**	**0.2**	

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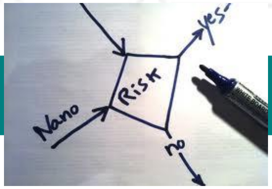
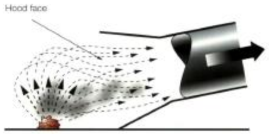
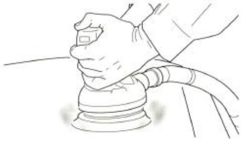
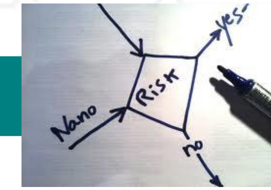


1. State of the Art regarding the effectiveness of LEVs

❑ Local Exhaust Ventilation (LEV)

Classification	Description	Assigned typical value	Guidance images
Local exhaust ventilation (LEV)			
- Capturing hoods			
Movable capturing hoods	Movable LEV systems such as hoods with extendable arms. The design of the system does not prevent work being performed outside the capture zone of the system and worker behaviour can influence the effectiveness of the system.	0.5	
Fixed capturing hoods	Fixed capturing hoods located in close proximity of and directed at the source of emission. The design is such that the work is performed in the capture zone of the ventilation system and the capture is indicated at the workplace.	0.1	
On-tool extraction	**LEV systems integrated in a process or equipment that cannot be separated from the primary emission source.**	**0.1**	



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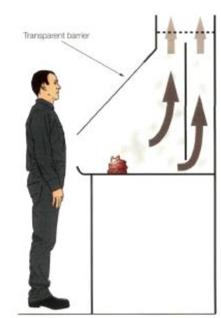
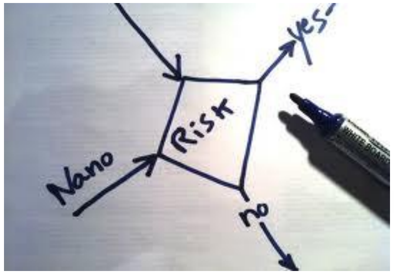
❑ Local Exhaust Ventilation (LEV)

Classification	Description	Assigned typical value	Guidance images
Local exhaust ventilation (LEV)			
- Enclosing hoods			
Fume cupboard	Any form of permanent encapsulation or encasing of the source of which maximally one side is open with a well designed local exhaust ventilation system (e.g. laminar air flow). The design of both the enclosure and the ventilation system is such that the influence of worker behaviour is minimal (e.g. an alarm system prevents the worker from using the fume cupboard in case the system is not working properly).	0.01	
Horizontal/downward laminar flow booth	In a horizontal laminar flow booth, contaminated air is extracted through holes situated at the rear of the booth which creates a horizontal laminar air flow. The air is filtered prior to being discharged to the atmosphere. The booth contains the source and has maximally one side open. In a downward laminar flow booth, a curtain of descending laminar air flow is created between the ceiling and the rear of the booth where exhaust grills are located in the lower section. The booth contains the source and has maximally one side open..	0.1	
Other enclosing hoods	**Any form of permanent encapsulation or encasing of the source of which maximally the front side is open with a proper local exhaust ventilation system.**	**0.1**	

2. Testing activities and progress so far



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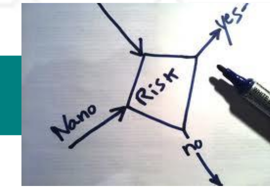


2. Testing activities and progress so far

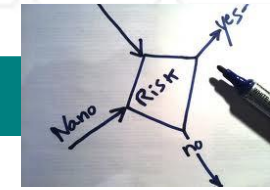
❑ Progress to date

- **Fume Cupboard**

- **Effectiveness testing**: The effectiveness of fume cupboards were conducted by means of repeated measurements wit a CPC/OPS system at the researcher's breathing zone under different locations.

- The operations included:

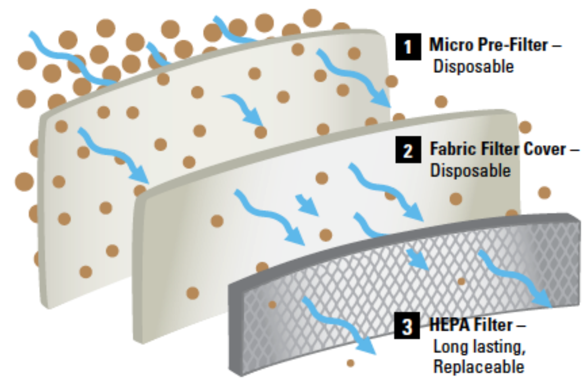
  - Opening and closing containers (Tsai et al. (2009)
  - Pouring or transferring particles from beaker to beaker (15 g /NP)
  - Mixing NPs with solvents / water
  - Operator motion: two arms shall be positioned inside the cabinet near the contaminant source



2. Testing activities and progress so far

❑ Scientific Results - Selection of RMMs

When using a local exhaust system, do not directly exhaust into the work environment any effluent (air) that is reasonably suspected to contain nanomaterials.



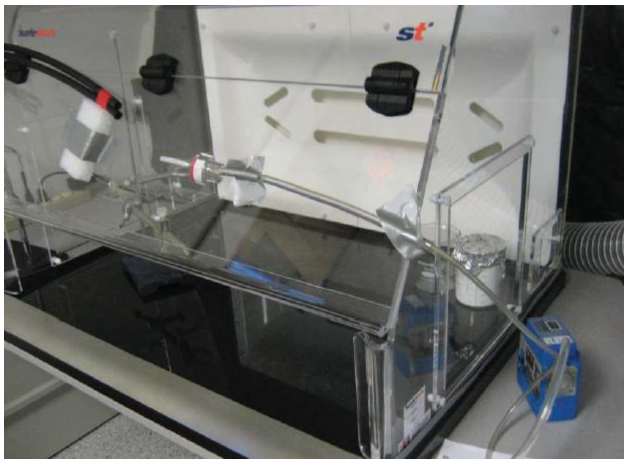
The **exhaust air should be passed through a HEPA filter** and, when feasible, released outside the facility.

Storage of **materials in the chemical hood should be minimized or eliminated.** Materials stored in the hood can adversely affect the containment by disrupting airflow. If items must be placed inside the hood, make sure they are placed near the back and do not block the air slots.

Effectiveness of Engineering controls (LEVs)

2. Testing activities and progress so far

- Scientific Results - Selection of RMMs



Powder-handling enclosure

Constant flow Fume Cupboard

Effectiveness of Engineering controls (LEVs)

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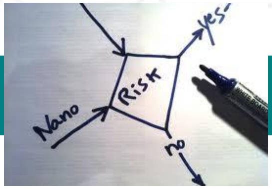

❑ Scientific Results - Selection of RMMs

Reference	RMM General Type	RMM Specific Type	Situation in enclosure			Situation outside enclosure			MPPS	Efficacy value
			N	Concentration	Size (nm)	N	Concentration	Size (nm)	nm	%
Huang et al 2007	15	Air curtain-isolated fume hood	-	-	-	-	-	-	-	Average and maximum leakage levels of SF6 concentrations 10^-3 p.p.m. or less
Lee et al 2007	15	Welding booth	-	conv 2.06E+06 / mod 4.86E+06	conv 162 / mod 190	-	conv 2.77E+05 / mod 1.80E+06	conv 187 / mod 159	-	conventional booth horizontal = 13,4%, modified booth horizontal = 37%
Tseng et al 2007a	15	Fume cupboard	-	-	-	-	-	-	-	4,95 ppm SF6 leakage at lower section with manikin, 0,58 ppm SF6 leakage without manikin
Tseng et al 2007b	15	Fume cupboard	-	-	-	-	-	-	-	1,25 ppm static SF6 leakage (peak) during sash opening, 1,7 ppm breathing zone / 1,4 ppm SF6 leakage during walk-bys, 0,5 ppm in breathing zone
Tsai et al 2009	15	conventional hood, a by-pass hood, and a constant velocity hood"	-	Conventional 100g Transferring 10287,5 pt/cc, Pouring 11539 pt/cc Bypass 100g Transferring 14106 pt/cc, Pouring 18339,5 pt/cc Conventional 15g Transferring 4209 pt/cc, Pouring 3653,5pt/cc Constant velocity 15g Transferring 1327,5 pt/cc, Pouring 1578,5 pt/cc	Ag 60 nm Al2O3 27-56 nm		Conventional 100g Transferring 2447 pt/cc, Pouring 2752 pt/cc Bypass 100g Transferring 1326 pt/cc, Pouring 12014 pt/cc Conventional 15g Transferring 3124 pt/cc, Pouring 3093pt/cc Constant velocity 15g Transferring 1698pt/cc, Pouring 1575pt/cc			Conventional 100g Transferring 76,2%, Pouring 76,2% Bypass 100g Transferring 90,6%, Pouring 34,5% Conventional 15g Transferring 25,8%, Pouring 15,3% Constant velocity 15g Transferring -27,9%, Pouring 0,2%

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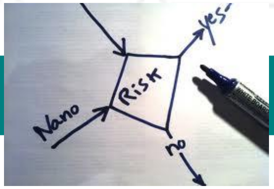

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			N	Concentration	Size (nm)	N	Concentration	Size (nm)	nm	%
Tsai et al 2010	15	constant flow hood, a constant-velocity hood, and an air-curtain hood			Al_2O_3 27-56 nm		-	-	-	The air-curtain hood was found to have a stable and very low particle release for all tested operating conditions, with a very small but measurable release occurring at the low sash position.
Heitbrink et al 2012	15	Ventilated booth inside a downflow dilution ventilation room		powder weigh out 14-17 pt/cc , cutting 5 pt/cc, grinding 3 pt/cc, cutting with band-saw 1,7E+06	band saw 7-30 nm		-	-	-	Efficient for powder weighing, cutting and grinding nanocomposites, not for cutting with band saw.
Lo et al 2012	15	Ventilated enclosure		N-EVS1 55831 pt/cc N-EVS2 63015 pt/cc S-EVS1 335548 pt/cc S-EVS2 746060 pt/cc	10-20 nm		N-EVS1 88 pt/cc N-EVS2 5196 pt/cc S-EVS1 23395 pt/cc S-EVS2 56472 pt/cc	10-20 nm		N-EVS1 99,84% N-EVS2 91,79% S-EVS1 93,03% S-EVS2 92,43%
Artous et al 2013	15	fume hood			65 nm					the analytical method (EN14175) with a nanoparticulate tracer of sodium fluorescein (NP) is more sensitive than helium (gas)

GRACIAS POR SU ATENCIÓN

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