Mapping occupational exposure to MNMs in construction- levels and strategies for risk assessment and risk protection

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Part I

Strategies for risk assessment

GA 280535)

Best Practice Guide- Risk Assessment

1. Mapping the construction sector & exposure scenarios to NOAAs
2. Risk Assessment
3. Best Practice

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1. Mapping the construction sector & exposure scenarios

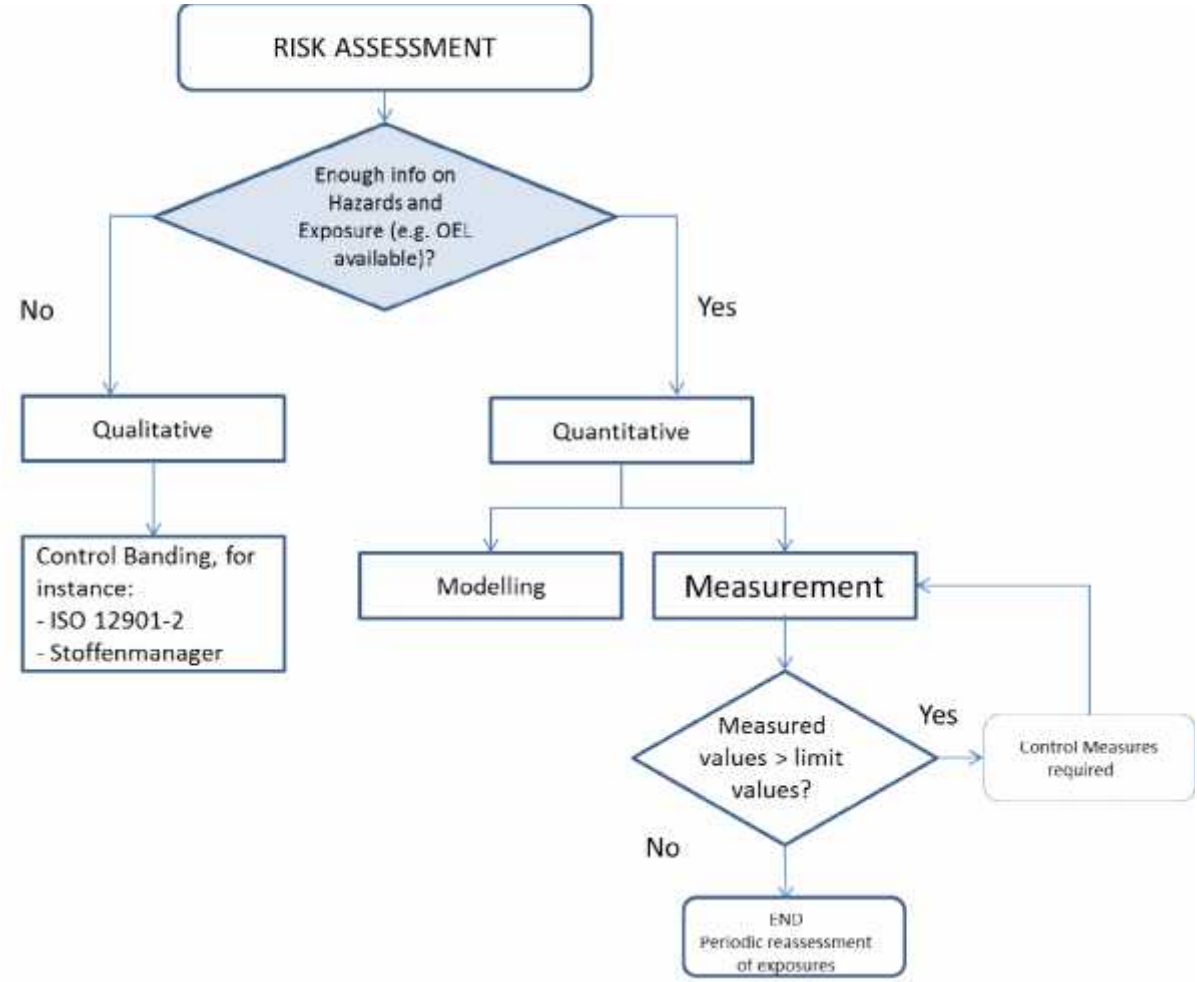
	Nano-object and application					
Life cycle step	**nano-TiO2** depollutant mortar	**nano-TiO2** self-cleaning coating	**nano-SiO2** self-compacting concrete	**nano-Clay**(fire retardant panels	**carbon nano-fibers** coating laminates	**nano-cellulose** insulations
Nano-object manufacturing	X	X	◯			
Manufacturing nano-enabled products and application	X	(X)	◯	◯	X	X
Use/maintenance: Machining	X	X	X	(X)	X	X
Demolition	X	X	X	(X)	X	X
Accidental fires	X	X	X	X	X	X

X scenarios measured at lab/pilot/industrial scale
◯ scenarios measured in Industrial Case studies

The results found that in general workers performing the tasks measured were not overexposed to NOAAs in the scenarios investigated; data of occupational exposure were below the limits proposed for the NOAAs by Scaffold.

2. Risk Assessment

Overview



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2. Risk Assessment

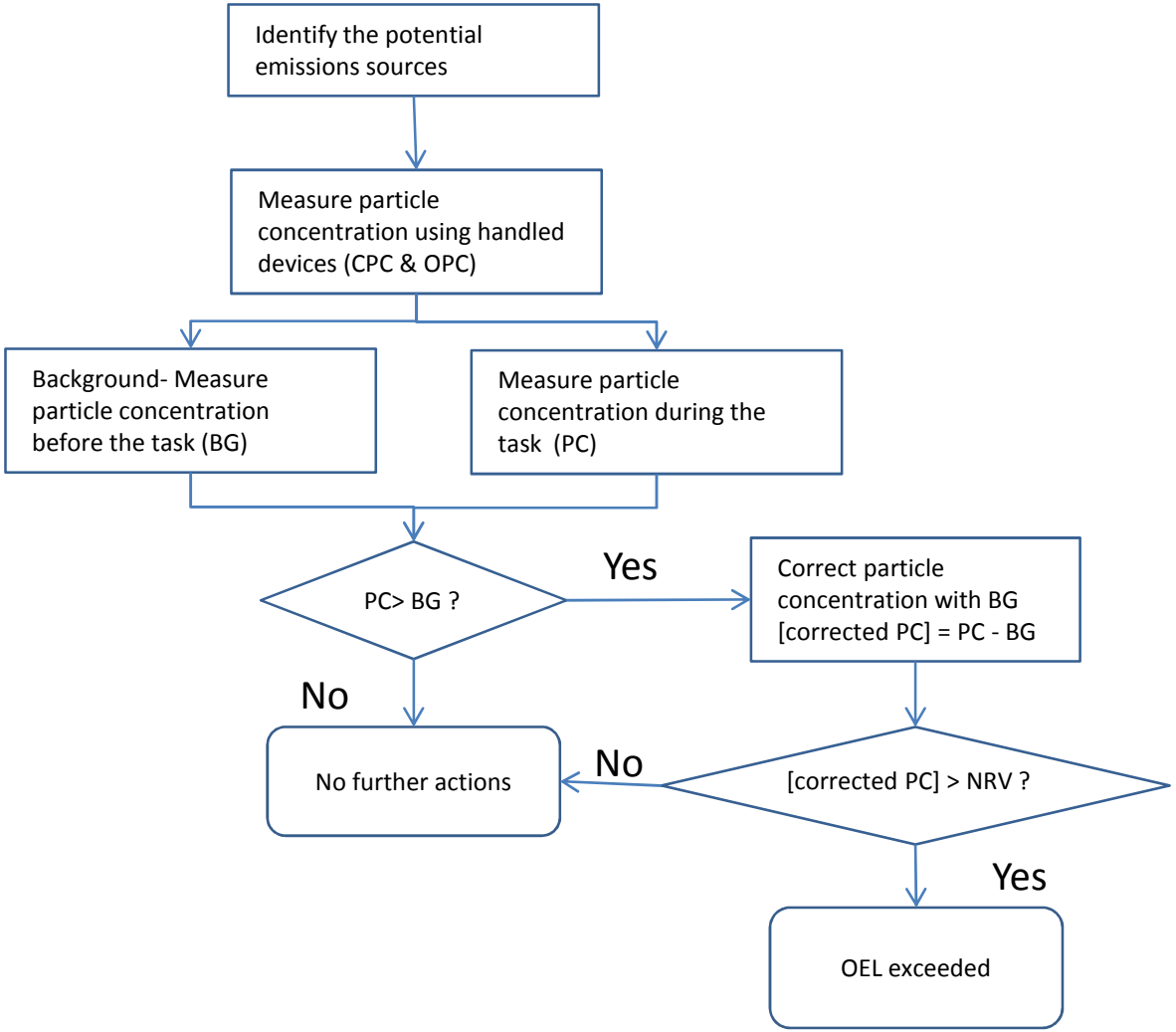
Quantitative Risk Assessment

Limits proposed in Scaffold

Nano-object	OEL (mg/m³) or fibers/cm³ (1)	Reference Values particles/cm³ or fibers/cm³(1)
nano-TiO2	0.1	40.000
nano-SiO2	0.3	40.000
nano-clay	0.3 (respirable) & 4 (inhalable)	40.000
Low toxicity dust	0.3 (respirable) & 4 (inhalable)	
nano-cellulose	0.01 (1)	0.01 (1)
Carbon nano-fiber	0.01 (1)	0.01 (1)

2. Risk Assessment

Metric: number concentration (p/cm^3)



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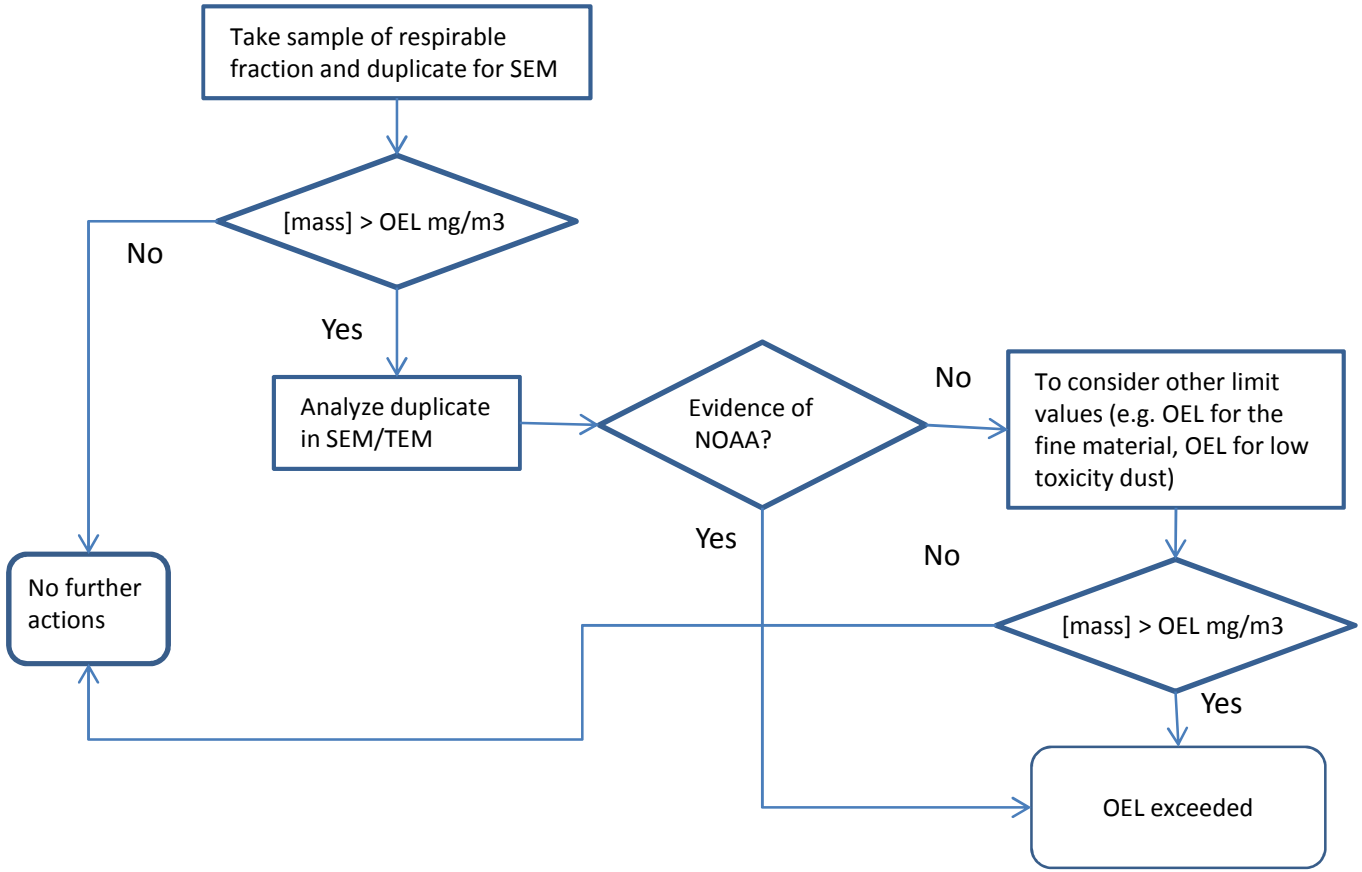
2. Risk Assessment

Metric: mass concentration (mg/m^3)



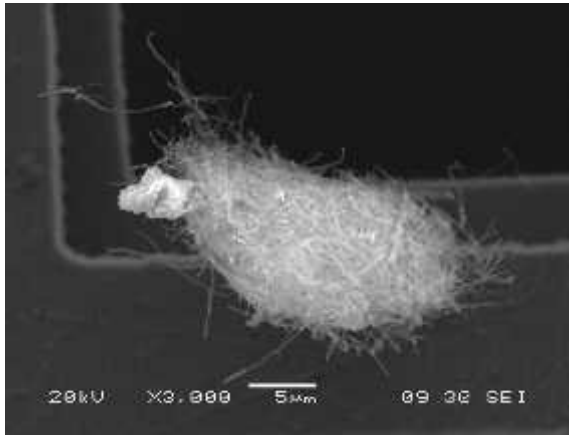
2. Risk Assessment

Fibers concentration (fibers/cm^3)

- Lack of consensus on the methods to quantitatively measure the fibers in a filter to be compared with the limit (0.01 fibers/cm3)

- Conservative approach: if there is evidence of the presence of fibers (SEM/TEM), then control measures would be required to avoid exposure to fibers (1).

- Machining of polymeric matrix doped with the fibers:
  - In these tasks a high release of particles is expected. However, although SEM analysis does not observe the presence of fibers, there may be **uncertainties about the release of free fibers** and moreover, about the **toxicity of the dust resulting** from these machining tasks.
  - Consequently, following a precautionary approach, the only recommendation that could be made at this moment is to control the exposure to this dust as much as possible (1)



(1) Inputs form the Group-Delphi Workshop on Risk Assessment (RA) and Risk Protection (RP), Nanosafe2014, 19 November, 2014.

3. Best practice

(some examples):

- When measuring particle concentration (particles/cm3) in particle-generated processes (e.g. machining tasks) the measurement would be the sum of both, particles generated on the processes plus the NOAA; for these cases the recommendation is to consider the global risk of both the conventional nanomaterials produced in the task and the NOAA (1)

- Mass concentration may be a more relevant metric when there are a release of particles around or bigger than 300 nm, which is the common scenario in construction

- Process-generated nanoparticles: overestimation of the mass measurements due to the lack of selective analytic technique (with some exceptions as n-TiO2).

  Approach: if no evidence of NOAA in SEM/TEM analysis, then, values measured may be compared with OELs for low toxicity dust (1).
  Exception: matrix filled with nano-fibers.

(1) Inputs form the Group-Delphi Workshop on Risk Assessment (RA) and Risk Protection (RP), Nanosafe2014, 19 November, 2014.

Conclusions (Risk Assessment):

- Scaffold has proposed strategies for the risk assessment of the 5 NOAAs in the scope of the project, including OELs+ measurement method: n-TiO2, n-siO2, nanoclays, CNF and nanocellulose.

- Currently there are still gaps to measure workers exposure to NOAAs, considering the different metrics, mass concentration, number concentration and specially for the nanofibers.

- The results of the measurements of occupational exposure made in Scaffold are encouraging and in general workers performing the tasks measured were not overexposed to NOAAs in the scenarios investigated; data of occupational exposure were below the limits proposed for the NOAAs by Scaffold.

- Currently there are few data of occupational exposure to NOAAs in construction: More data from real scenario would help to incorporate in a safe way this new materials in the sector.

Thank you !

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Strategies for Risk Protection

RISK SHOULD BE AVOIDED WHEREVER POSSIBLE

RISK ASSESSMENT is the key element in the PREVENTION PROCESS

PREVENTIVE MEASURES → RISK PROTECTION

AND

- INHALATION, INGESTION
- DERMAL PENETRATION

WP4 of the Scaffold project is based on the risk protection

Different real scenarios and lab-scale experiments

≠ ENGINEERING CONTROLS
COLLECTIVE PROTECTION

≠ PERSONAL PROTECTION
RESPIRATORY and DERMAL

≠ Types of NPs (SiO_2, TiO_2, nanoclay, carbon nanofibers, nanocellulos)

RESULTS → BEST PRACTICE GUIDE on RISK PROTECTION for the construction sector

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Strategies for RP

INVESTIGATED SCENARIOS DURING THE PROJECT

With different industrial partners as:

- TECNAN
- ICECON
- MOSTOSTAL
- ACCIONA
- ROSSAL
- NETCOMPOSITES

STEPS OF LIFE CYCLE	N°	SCENARIOS
Synthesis	1	Production of NPs (TiO_2, SiO_2, nanoclay) in powder form
Handling/Formulation	2	Collection, transferring, weighing and bagging a big quantity of NPs (TiO_2, SiO_2, nanoclay) and NFs (carbon NFs, cellulose NFs) in powder form (>100g)
	2bis	Collection, transferring, weighing and bagging a small quantity of NPs (TiO_2, SiO_2, nanoclay) and NFs (carbon NFs, cellulose NFs) in powder form (<100g)
	3	Dissolution of NPs in water (TiO_2, SiO_2, nanoclay) Powder form to liquid state
Manufacturing NanoMaterials (MNMs)	4	Manufacturing insulating and fire resistant panels with nanoclay in solid form.
	5	Manufacturing and formulation of self-cleaning external coatings with nano TiO_2 in liquid state.
	5bis	Manufacturing and formulation of self-cleaning external coatings with cellulose NFs in liquid state.
	6	Manufacturing and formulation of mortar with nano TiO_2 in solid state
	7	Manufacturing and formulation of concrete with nanoSiO_2 in solid state
	8	Manufacturing bituminous road-surface pavements with carbon NFs in solid state
Using MNMs	9	Drilling holes, machining, sanding, cutting materials containing NPs. Generation of aerosolized and solid NPs
	9bis	Drilling holes, machining, sanding, cutting materials containing NFs. Generation of aerosolized and solid NPs
	10	Applying a mortar containing TiO_2 on a wall in a solid state
	11	Spraying sol-gel mortar containing TiO_2 on a wall in a liquid state
Cleaning and Maintenance	12	Of filters and equipment used to produce NPs and NMNs by a wet procedure
End of Life of NPs and NFs	13	Demolishing a work-cabin containing NPs. Generation of dust and aerosolized NPs
	13bis	Demolishing a work-cabin containing NFs. Generation of dust and aerosolized NPs
	14	Accidental fire of panels containing NPs. Generation of aerosolized NPs

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Strategies for RP

COLLECTIVE PROTECTION SYSTEMS INVESTIGATED

Task leader CIOP
Elzbieta Jankowska

Type of ventilation systems	Pictures (examples)
Mechanical general ventilation – openings of supply system – openings of exhaust system	   
Local ventilation - elements of extractor hoods system	 
Local ventilation – arm hood – side hood	 
Enclosed ventilation – fume hoods	 
Enclosed ventilation – elements of closed reactor with regular opening	 
Full containment – glove box	

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PERSONAL PROTECTION SYSTEMS
1) RESPIRATORY DEVICES INVESTIGATED

Task leader CIOP
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Małgorzata Okrasa

Type of respiratory device	Pictures
FFP2 and FFP3 filtering half masks - used to protect the respiratory system against aerosols containing solid and liquid aerosols. - not to be used if oxygen content in the air is lower than 19% v/v, as well as in inadequately ventilated or very compact spaces, such as tunnels, wells, or tanks.	
Half masks P2 and P3 - used with a variety of filtering elements (particle filters, gas filters, or a combined filters), depending on the type of pollutants present, to ensure protection against aerosols and/or vapors and gasses. - connected with filtering elements it should not be used if oxygen content in the air is lower than 19% v/v, as well as in inadequately ventilated or very compact spaces, such as tunnels, wells, or tanks. - half masks can be used also with a breathing apparatus to give protection against all air pollutants and oxygen deficiency.	
FFA1P2 and FFA2P3 filtering half masks against organic vapours and/or gases and particles - used when workplace hazards include solid and/or liquid aerosols as well as gasses and/or vapors of organic substances. - not to be used if oxygen content in the air is lower than 19% v/v, as well as in inadequately ventilated or very compact spaces, such as tunnels, wells, or tanks.	 
Full face masks P3 - the most typical and effective RPDs, cover the whole face of the user, giving protection to the respiratory system, to the eyes and face. - can be used with air-purifying elements, compressed air line breathing apparatuses and closed and open circuit self-contained breathing apparatuses (SCBAs).	
Powered filtering device with hood, TH2 protection class - the hood covers the entire head of the user, ensure protection to the respiratory system and to other parts of the face and head. - hoods may contain eye and face protecting elements, a helmet protecting the head against mechanical impacts, and earmuffs. - the powered filtering device is one of the most comfortable RPD types. - slight overpressure in the breathing zone do not increase breathing resistance during use and prevents the intrusion of contaminants.	

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PERSONAL PROTECTION SYSTEMS
2) DERMAL PROTECTION INVESTIGATED

Type of gloves for dermal protection	Pictures
Gloves A (chemical handling) -colour **rubber gloves** are ideal for **chemical handling**, heavy duty industrial applications, on assembly lines, for use with pesticides, within the construction industry, within laboratories, **industrial cleaning and manufacturing**. They offer protection against a wide range of detergents, alcohols, alkalis, acids, caustics and salts.	
Gloves B (mechanical risks) **Nitrile coated gloves** protecting against **mechanical risks**. The inner liner is a 100% jersey, with a cotton knitted safety cuff. Ideal for handling abrasive materials such as castings, wrought iron and bricks. **Not required for chemical protection.**	
Gloves C (chemical and mechanical) **100% nitrile** high quality gloves providing resistance to a wide range of **chemicals**. Resistant to a broad range of chemicals particularly petroleum based solvents, oils and grease. Good protection against **abrasion** and snags due to their thickness.	
Gloves D (chemical) **100% nitrile gloves** very sensitive. The finger tips have a textured pattern that helps with dexterity. They provide superior protection from most **chemicals**.	

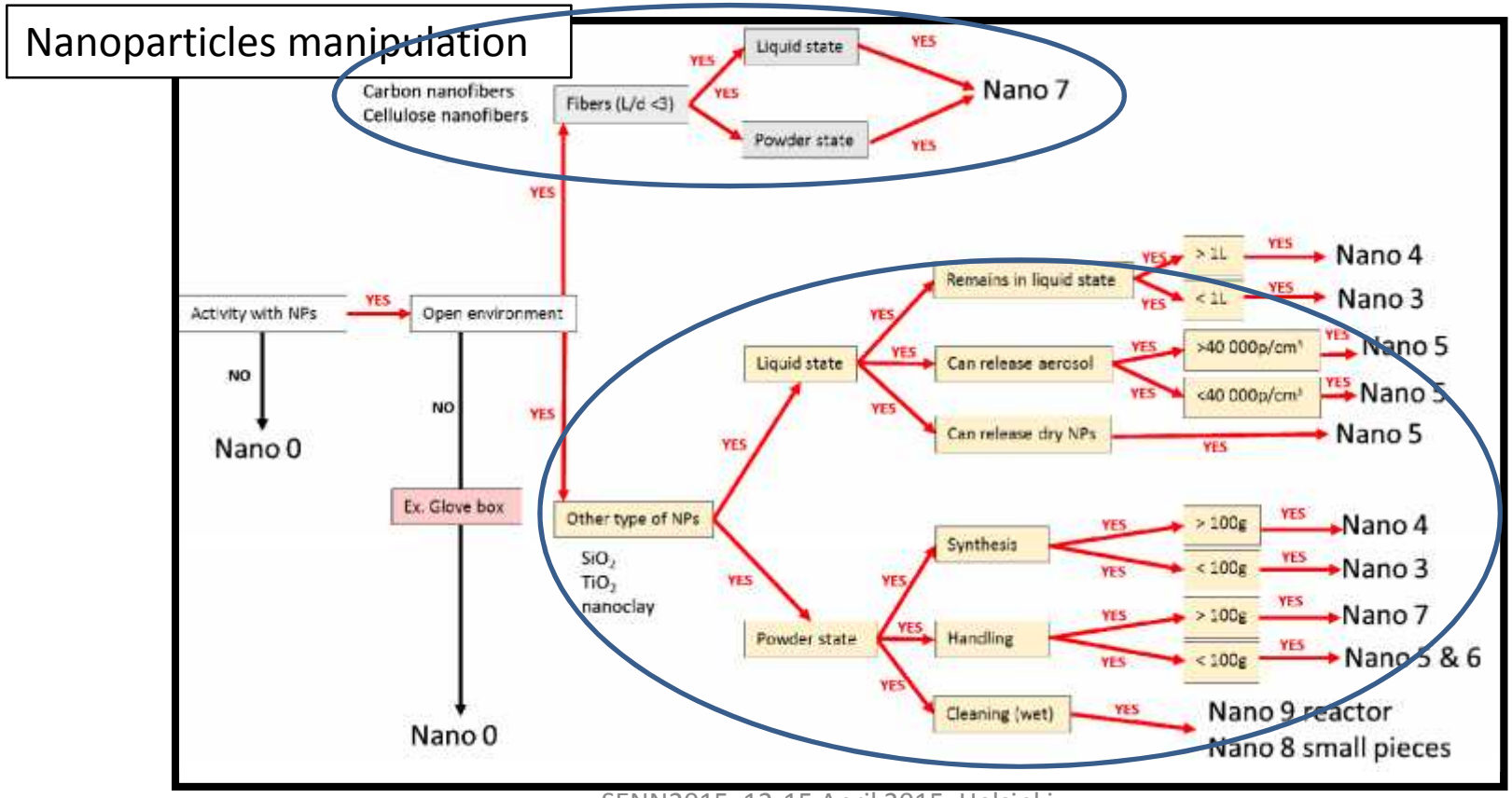
Type of cloth	Pictures
Fleece jacket composed of 100% polyester **Non-woven** material Density: 300-340g/m2 Thickness: 3.8 mm Porosity: 90-95%	
Jacket composed of 65% polyester and 35% of cotton **Woven** material Density: 245-350g/m2 Thickness: 500 microns Porosity: 50-60%	
Rain jacket composed of polyamide coated with polyurethane **Coated** material **Woven** material Density: n.a. Thickness: 340 microns Porosity: 20-30%	
Chemical protective clothing category 3, type 5 and 6 High protection against particles, splashing aqueous liquid **chemicals** (up to 0.13 bar pressure) and inorganic liquids. Durability because resistant to tearing, puncture and **abrasio**n.	

Task leader CEA Delphine Boutry

Strategies for RP

Based on the results, we made 2 decision trees: 1 for NPs and 1 for MNMS manipulation.

We distinguish nanoparticles and nanofibers because of their morphology (length-diameter aspect ratio larger than 3) which is in relation with their toxicity as asbestos fibers



Strategies for RP

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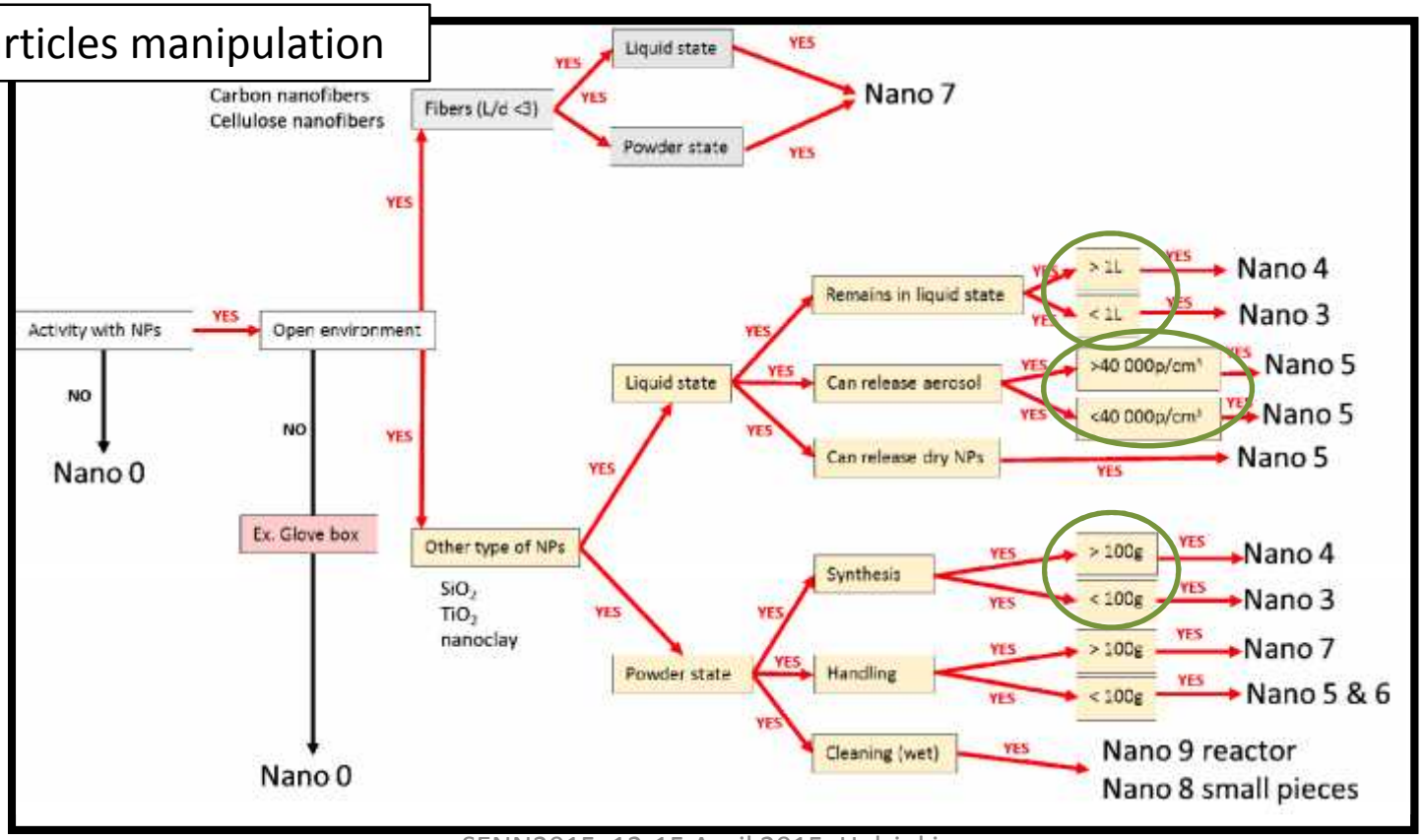
The limit values for liquid (1L) and powder (100g) were selected because many products are conditioned with this volume and this weight. For aerosolized particles we use the limit recommended by IFA (40 000 p/cm^3) (Institut Für Arbeitsschutz der DGUV)

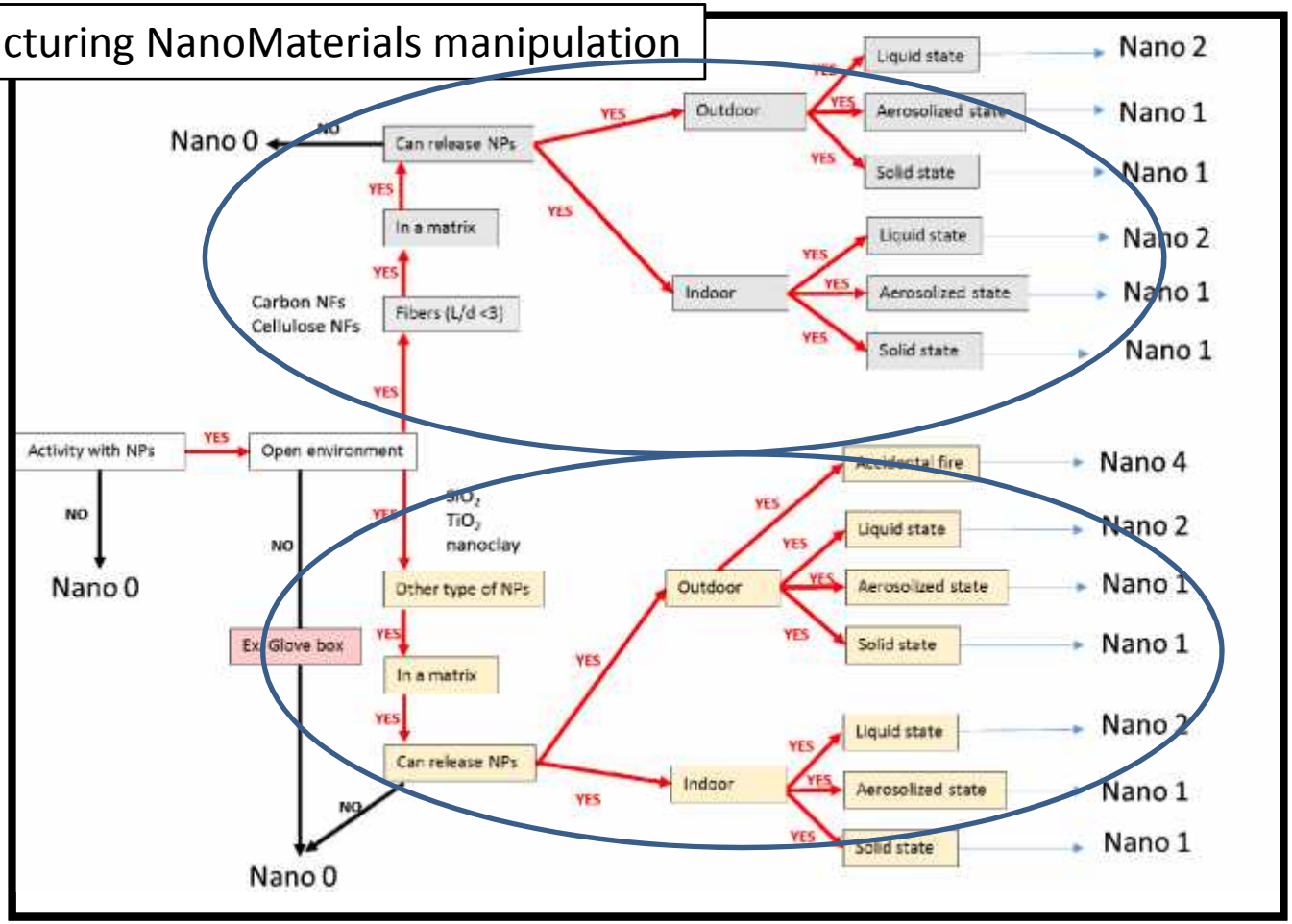
Nanoparticles manipulation



Strategies for RP

We also distinguish nanoparticles and nanofibers because of their morphology (length-diameter aspect ratio larger than 3) which is in relation with their toxicity as asbestos fibers

Manufacturing NanoMaterials manipulation



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Strategies for RP

9 levels of hazards are distinguished: from Nano 9, the highest hazard to Nano 0, the lowest hazard. For each level, different requirements for protection measures are given:

Levels of hazards increased

Examples	Type of work
Nano 0 1) No engineering control systems against nano hazards 2) No respiratory equipment against nano hazards 3) No dermal protection equipment against nano hazards	No NPs or work in a glovebox
Nano 1 1) General mechanical ventilation system with F7+H14 air filters 2) FFP3 filtering half mask in all cases (indoor, outdoor) 3) Safety glasses, non-woven clothes like fleece jacket, 1 pair of nitrile gloves (B)	Drilling holes in a panels Applying a mortar on a wall, Demolishing a work cabin, Cleaning a room after accidental fire…
Nano 3	
Nano 4 1) General mechanical ventilation system with F7+H14 air filters 2) No mask if closed environment (reactor) FFP3 filtering half mask if open environment Best fitted mask with powered filtering device incorporating a TH2 hood / full face mask with particle filter P3 if no collective protection **AND** open environment 3) Safety glasses, lab coat, 1 pair of nitrile gloves (D). Safety glasses, chemical protecting clothing cat.3, 1 pair of nitrile gloves (B) if accidental fire.	Synthesis in a closed reactor of a large amount of NPs
Nano 5, 6, 7, 8	
Nano 9 1) General mechanical ventilation system with F7+H14 air filters **AND** local exhaust ventilation 2) FFP3 filtering half mask if collective protection. Best fitted mask with powered filtering device incorporating a TH2 hood / full face mask with particle filter P3 if no collective protection 3) Safety glasses, 2 pairs of adapted nitrile gloves (C and D) and chemical protective clothing cat.3 in all cases.	Cleaning of a reactor after synthesis

Conclusions for Risk Protection:

- Two decision trees have been made, one for the **manipulation of NPs** and the second for the **manipulation for MNMs**, allowing us to classify 9 levels of hazards present **in the construction sector**.

- Recommendations are given for ingestion, inhalation and dermal contact.

- Feature of this sector: work INDOOR and OUTDOOR:

  If OUTDOOR → no collective protection

  If INDOOR, collective protection has to be implemented at first.

- If no collective protection OR collective protection is not sufficient, personal protections equipment have to be implemented

- The aim of this study was to propose **collective and personal protections against NPs** which were **appropriate to this sector** and to each scenarios, with **minimizing the burden**.

- For the recommendations, we assume that all the NPs are always isolated, even it is not the case in real life because industrials can't observe NPs by SEM or TEM (**precautionary principle**).

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THANK YOU VERY MUCH FOR YOUR ATTENTION

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