Directive on working with nanomaterials LEX 1.5.5

13th May 2013, status as at 15th March 2021

The Direction of the Ecole polytechnique fédérale de Lausanne hereby adopts the following :

Preamble

In October 2011, the European Commission adopted the following definition of a 'Nanomaterial':

"A natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm - 100 nm." By derogation from the above, "fullerenes, graphene flakes and single wall carbon nanotubes with one or more external dimensions below 1 nm should be considered as nanomaterials."

The present document concerns only **engineered nanomaterials (ENM)**, nanolayers with a dimension of less than 1nm, and multiwall carbon nanotubes.

Initial experimental studies with ENM in cell cultures and laboratory animals have shown that the biological response to certain ENM can be greater in comparison to the response to larger particles with the same chemical composition (for the same mass dose). In addition to the particle number and surface area (surface per unit of mass), other particle characteristics may influence the biological response. These include solubility, shape, charge and surface chemistry, catalytic properties, adsorbed pollutants (and other intentional and unintentional surface changes), as well as the degree of agglomeration.

Understanding of the relationship between physical/chemical properties and their dose/response is essential for improving decision making.

Exposure limit values have only been established for a small number of compounds produced in Switzerland or internationally. At the present time, they have been established for nanoparticles of TiO_2, for which the indicative exposure limit is set at 0.3 mg/m^3 (alveolar fraction) and carbon nanotubes and nanofibers (length more than 5 µm, diameter less than 3 µm, and ratio of the length and diameter more than 3:1), for which the limit is set at 0.01 fibre/ml.

In the absence of complete scientific evidence, the potential threat of newly developed materials on human health and the environment is assumed to be such that precautionary measures should be taken until the material is known to be safe. Lack of scientific certainty should not be used as a reason for postponing reasonable measures that could prevent human exposure and environmental release, and it is therefore prudent to implement a combination of technical, organisational and personal protective measures to minimize potential exposure to researchers.

This directive is based on the project[1] developed by the "Nanosafe team", involving occupational safety and health specialists and ENM scientists/users. As the scientific community continues to gather data to assess health and safety risks associated with ENM, the present document will be updated.

[1] Journal of Nanobiotechnology 2016 **14**:21, **DOI:** 10.1186/s12951-016-0169-x

Article 1 Instructions

[1] If you are concerned with ENM production and/or use, use the decision tree provided in Annex 1 to determine the potential hazard level to which your ENM belongs. Each type of ENM must be analysed separately. For hybrid particles, composed of two or more chemical elements and components, the decision tree must be applied to each element/component separately and consideration given to the highest of the obtained H levels to continue the analysis.

[2] For the assigned potential hazard level (H1, H2 or H3), employ the corresponding decision tree in Annex 2, 3 or 4 to determine the Nano safety laboratory level. The decision tree must be used to analyse each step of the process (weighing, synthesis, etc.) as they represent different activity emission potential. As a result of the analysis, the different phases of the processes will be classified as Nano 1, Nano 2 or Nano 3. The laboratory (physical space) is then classified into the highest obtained Nano safety level.

If a laboratory is classified Nano 2 or Nano 3, the head of the laboratory should contact the Department of Security, Safety and Facilities Operations (DSE-OHS) in order to analyse their process in greater detail and to consider the possibilities for reducing the Nano class or regrouping activities. As a result of this more detailed analysis, a 'definitive' Nano class of the laboratory is defined.

[3] Preventative and protective measures corresponding to all Nano laboratory levels are specified in Annex 5.

The preventative and protective technical, organisational and personal measures to be taken for each individual Nano safety level are specified in Annex 6 (Nano 1), Annex 7 (Nano 2) and Annex 8 (Nano 3).

Waste management and disposal is explained in Annex 9.

[4] A preventive medical examination (with a five year interval) is mandatory for all those who:

1) Work in areas classified Nano 2 and Nano 3;
2) Have an annual duration of exposure of more than 30 days or 200 hours.

If you satisfy these two criteria, please send an email to: sante@epfl.ch. Please specify the type and class of nanomaterial and the duration of exposure.

Article 2 In case of accident

In case of a powder spill, call 115 immediately, then refer to the current spill procedure described on the DSE-OHS website (http://securite.epfl.ch).

Article 3 Entry into force

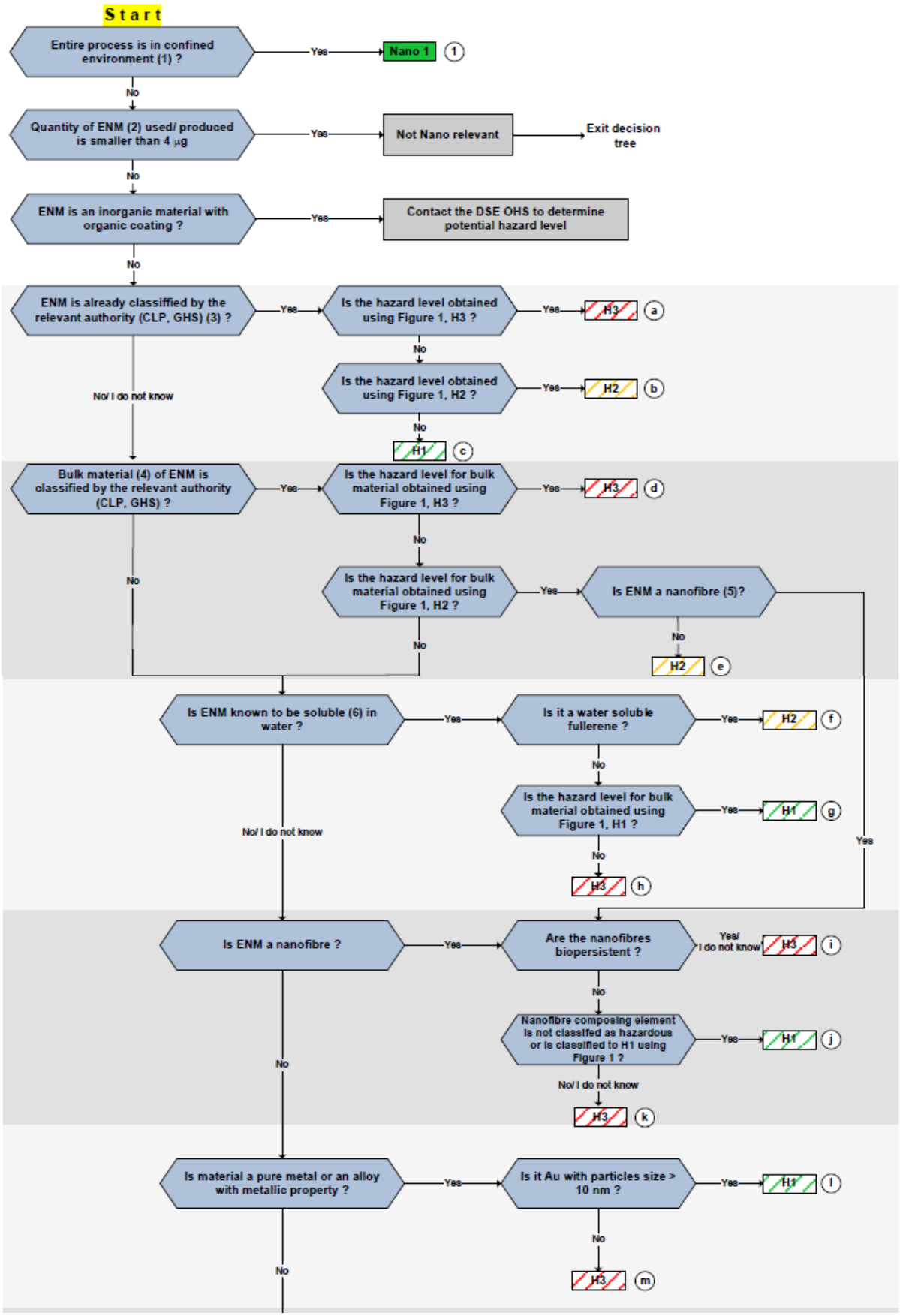
The present directive entered into force on 13th May 2013 (version 1.0) and was revised on 1st November 2016 (version 1.1), on 13th April 2018 (version 1.2) and on XX XXXX 2021 (version 1.3).

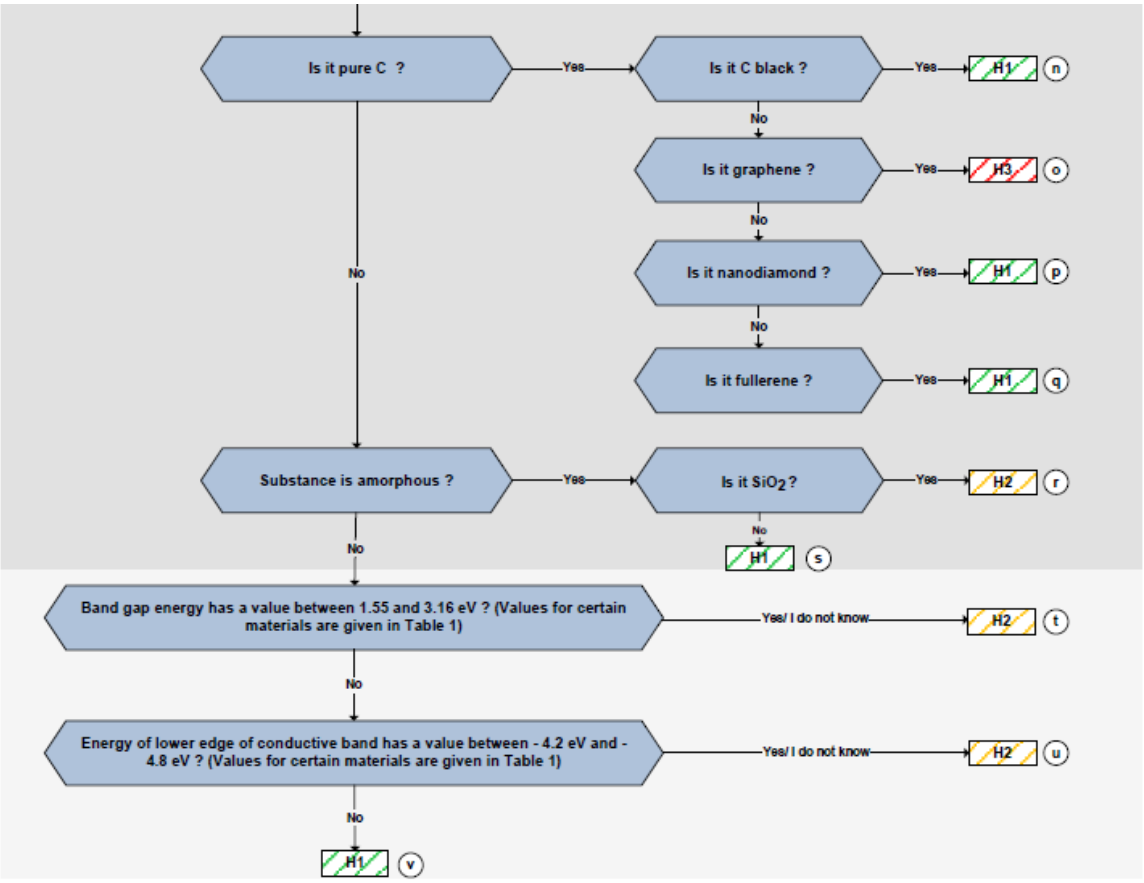
On behalf of the EPFL Direction:

President:
Martin Vetterli

Director of Legal Affairs:
Françoise Chardonnens

Annex 1. Decision tree for potential hazard level determination





Explanations, Figures and Tables relating to Annex 1

(1) Examples are: glove box, glove bag or sealed chamber.

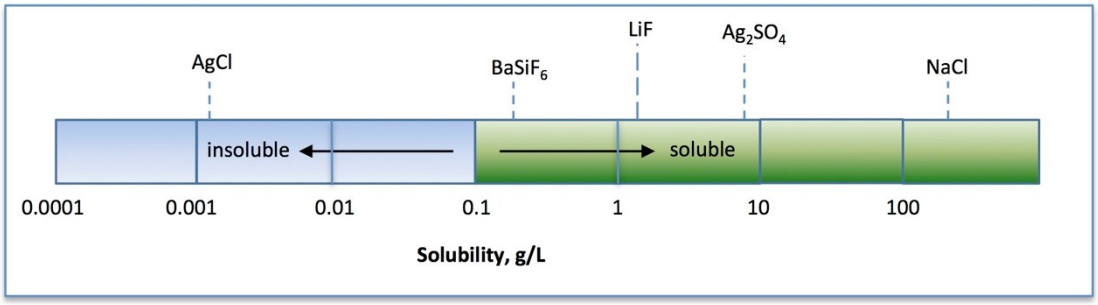
(2) Engineered nanomaterials (ENM): manufactured (engineered) material having at least one external dimension in the size range 1 nm - 100 nm.

(3) Information on material classification can be found in paragraph 2 of the material Safety Data Sheet (SDS).

(4) Bulk material of ENM: material with the same chemical composition and crystalline phase as the ENM, but with all external dimensions larger than 100 nm.

(5) Nanofiber: an ENM with two external dimensions in the nanoscale and for which the third dimension is significantly larger. Biopersistant fibres have the ability to remain in the lung in spite of the lung's physiological clearance mechanisms.

(6) Solubility in water with pH between 5 and 7. If needed, use the chart below as a guideline (consider as soluble if in the green coloured zone and insoluble if in the blue coloured zone).



Solubility does not change significantly compared to the bulk value for particles between 10 and 100 nm. The most significant enhancement in the calculated solubility is typically expected for very small particles below 10 nm. If you are handling particles of such sizes, use the Ostwald - Freundlich equation to estimate the influence of particle size to solubility and re-evaluate according to the chart above:

$$S = S_o \exp\left(\frac{2\gamma V}{RTr}\right)$$

S is the solubility (in mol kg^{-1}) of spherical particles
R is the radius (m)
S_0 is the solubility of the bulk
V is the molecular volume (m^3 mol^{-1})
γ is the surface tension (J m^{-2}). The typical value for oxides is 0.5 J
R is the gas constant 8.314 (J/mol K)
T is the temperature (K)

Explanations, Figures and Tables related to Annex 1 (continued)

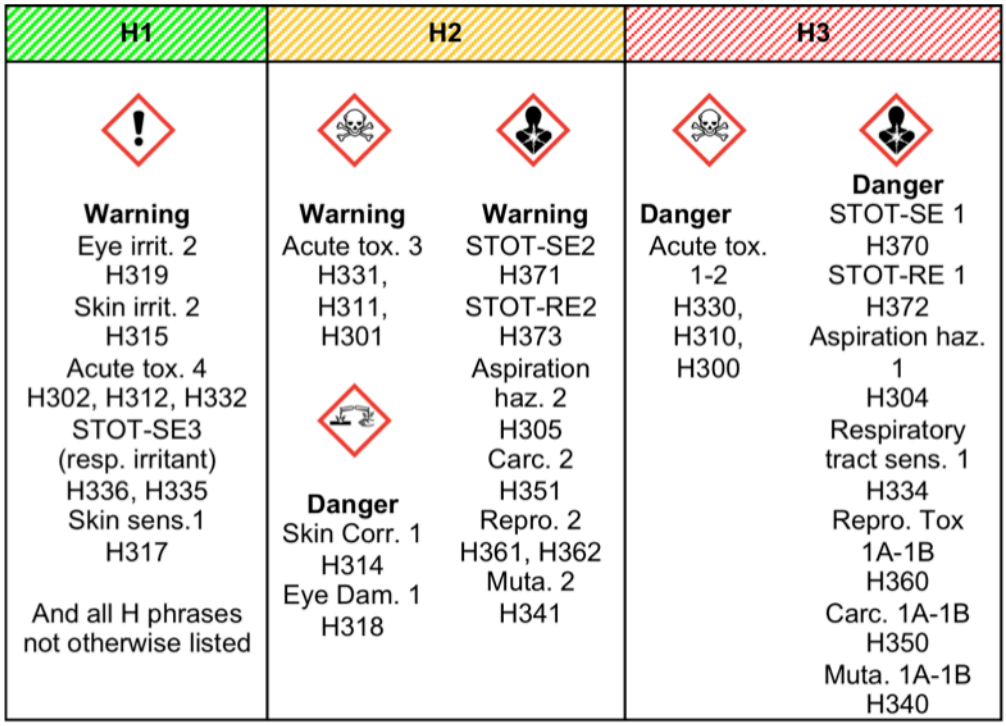
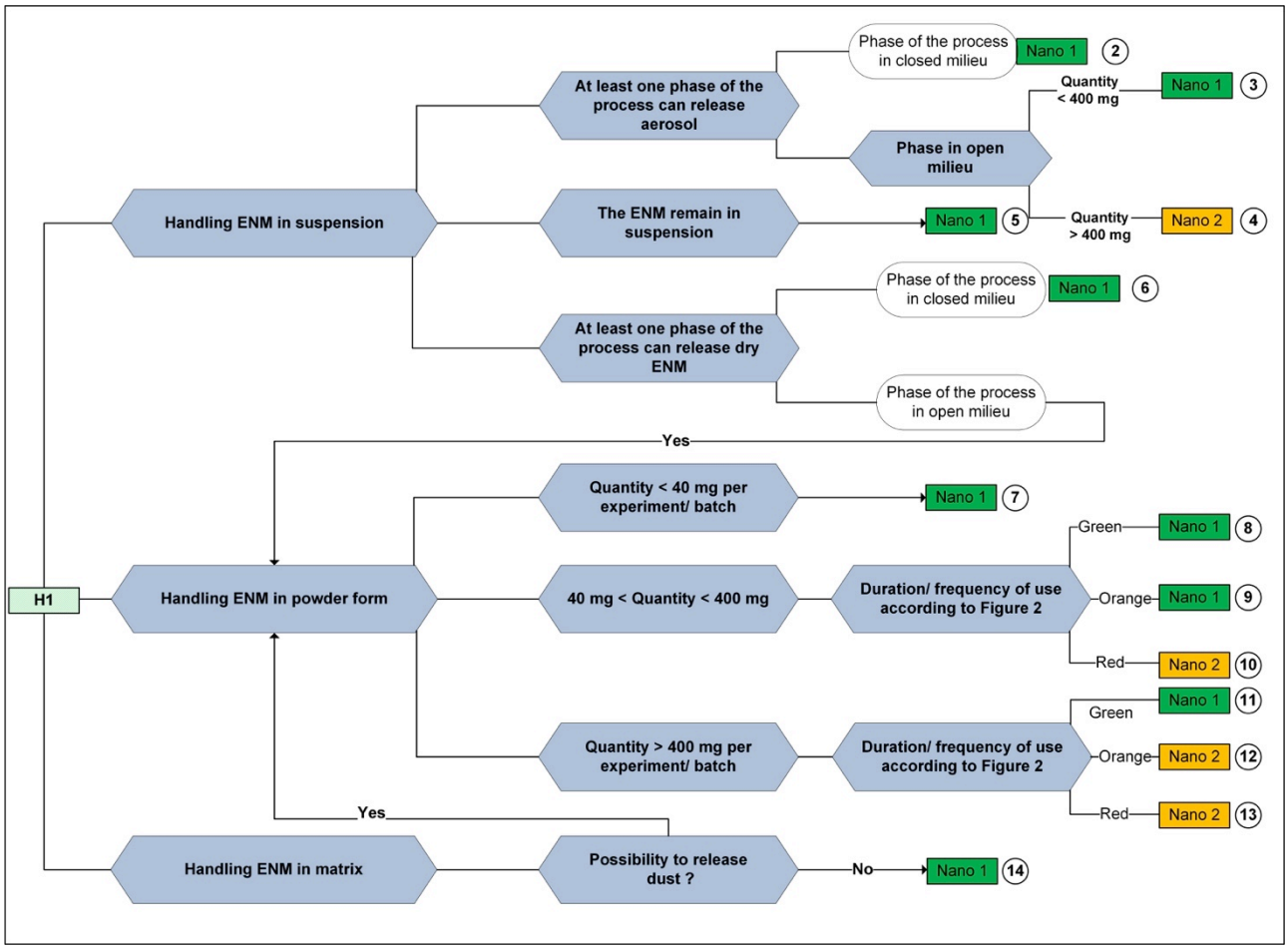


Figure 1. Classification of chemical substances into three hazard levels. Source of pictograms: Globally harmonized system of classification and labelling of chemicals (GHS), United Nations Economic Commission for Europe, 2011

Table 1. Table with calculated values of band gaps and lower levels of the conductive band of some selected materials as functions of their particle size.

Substance	Bandgap (eV)			Energy of lower level of conductance band (eV)		
	5 nm	10 nm	25 – 100 nm	5 nm	10 nm	25-100 nm
CuO_2	2.38	2.22	2.17	- 4.85	- 4.91	- 4.94
Alpha Fe_2O_3	2.23	2.05	1.99	- 4.87	- 4.96	- 4.99
Gamma Fe_2O_3	2.67	2.49	2.43	- 4.69	- 4.78	- 4.80
Fe_3O_4	2.09	1.91	1.85	- 4.88	- 4.97	- 4.99
WO_3	3.45	3.15	3.05	- 5.33	- 5.48	- 5.53
CoO	2.71	2.49	2.41	- 4.27	- 4.38	- 4.42
Mn_2O_3	3.23	3.05	2.99	- 4.53	- 4.62	- 4.65
Ni_2O_3	3.62	3.44	3.38	- 4.19	- 4.28	- 4.31
TiO_2 Anatase	4.09	3.52	3.33	- 3.78	- 4.06	- 4.16
TiO_2 Rutile	3.13	3.07	3.05	- 4.52	- 4.55	- 4.56
SnO_2 Rutile	4.25	4.06	4	- 3.88	- 3.98	- 4.01
CeO_2	3.89	3.71	3.65	- 3.68	- 3.77	- 3.79

Annex 2. Decision tree for Nano laboratory determination for potential hazard level H1



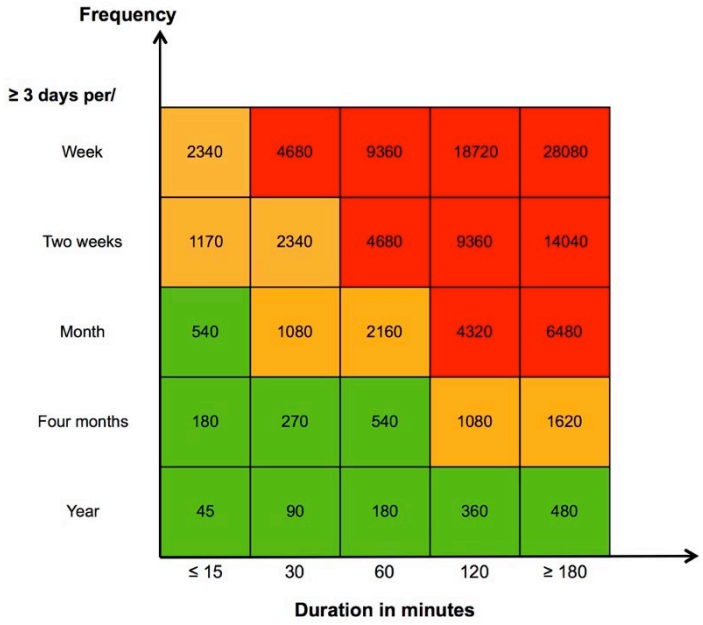
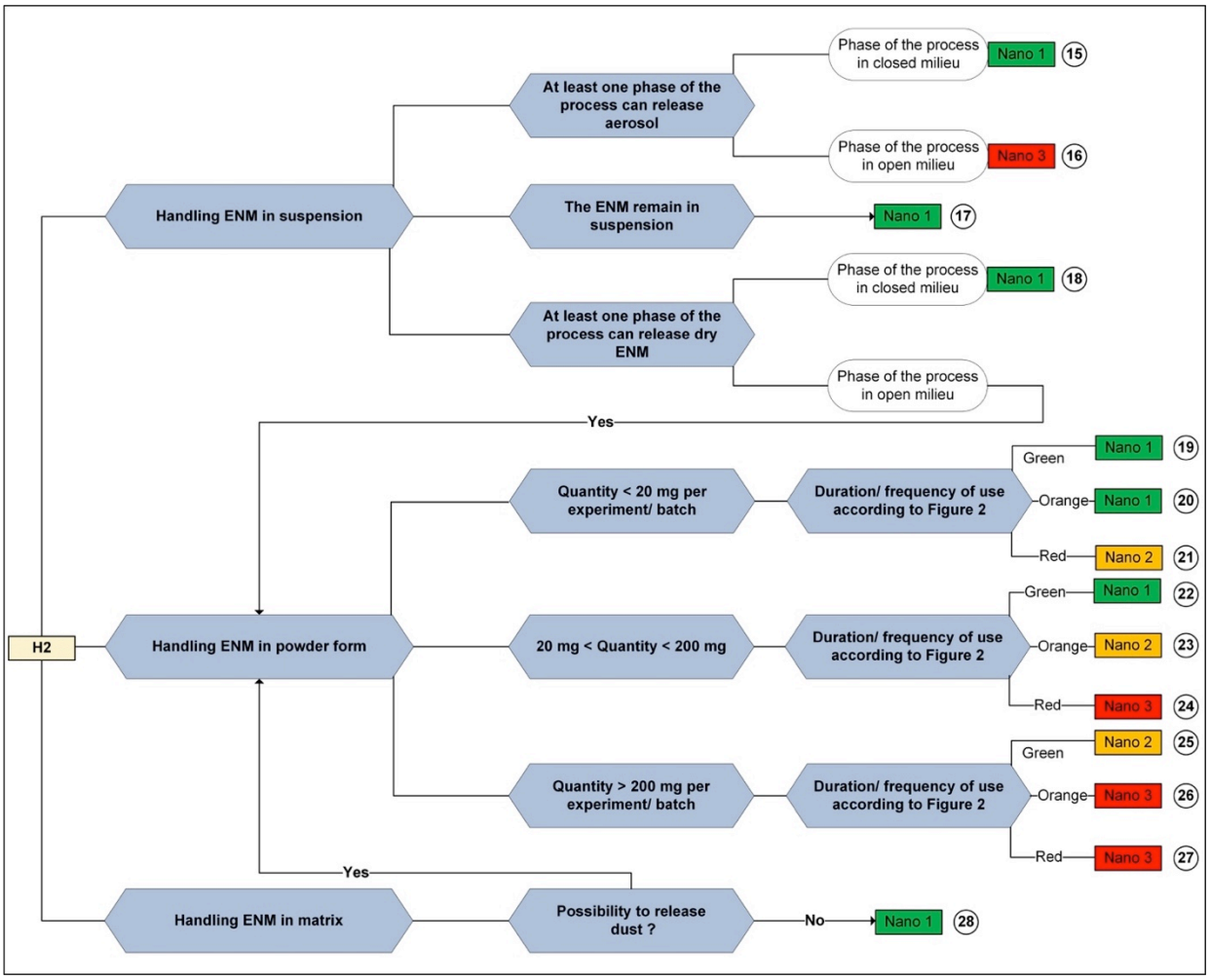


Figure 2. Matrix combining duration and frequency of operation for powder handling. Abscissa: typical durations of operations in minutes; ordinate: the number of work days in a year.

Annex 3. Decision tree for Nano laboratory determination for potential hazard level H2



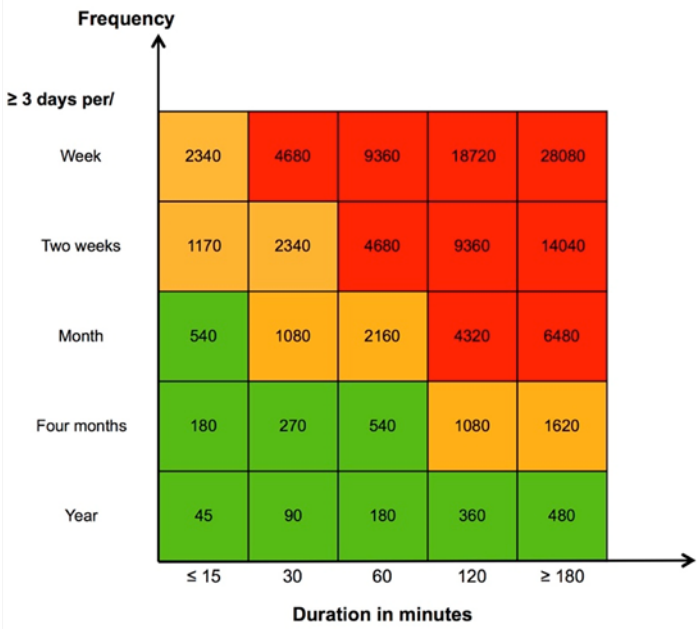
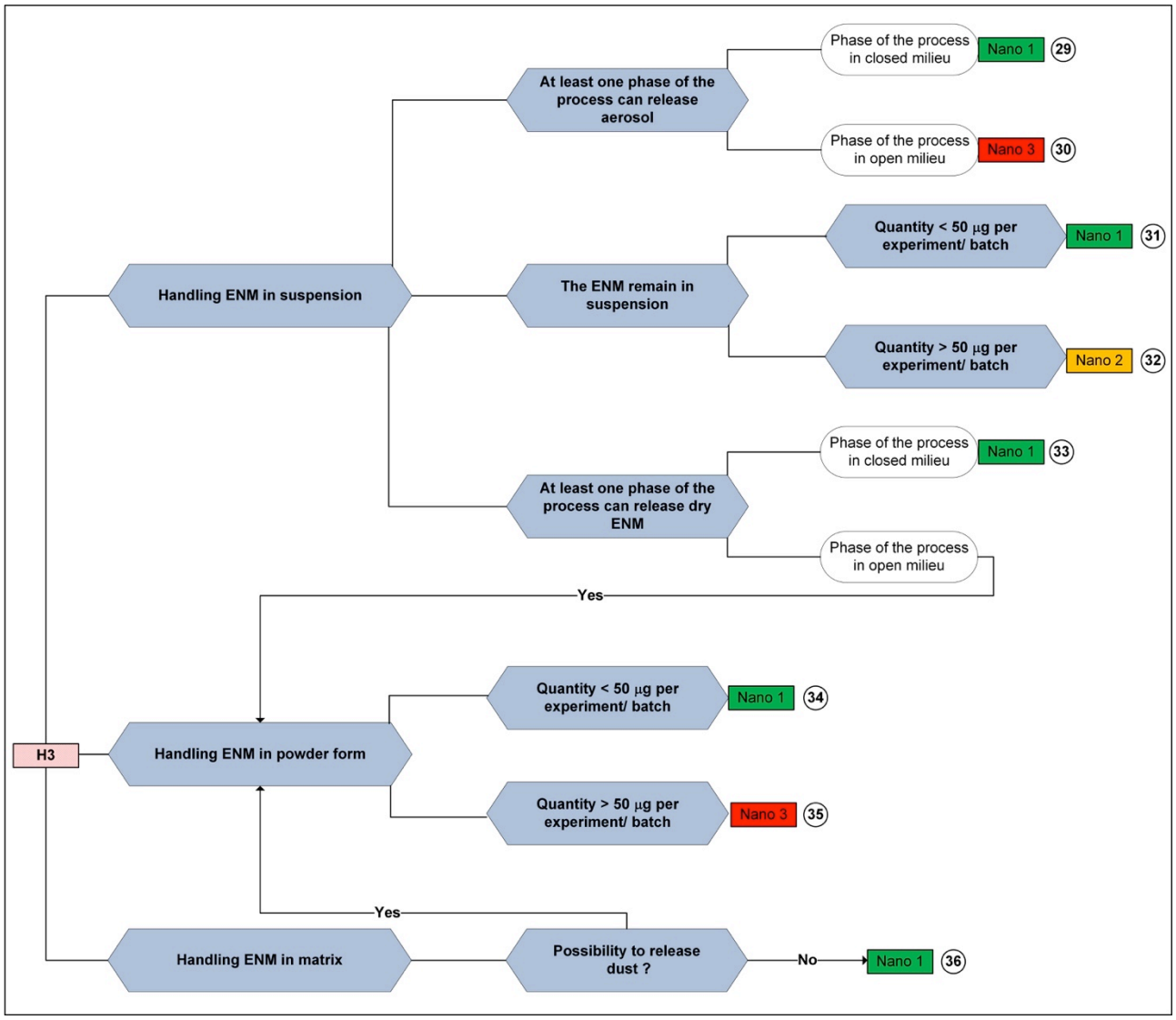


Figure 2. Matrix combining duration and frequency of operation for powder handling. Abscissa: typical durations of operations in minutes; ordinate: the number of work days in a year.

Annex 4. Decision tree for Nano laboratory determination for potential hazard level H3



Annex 5. Mitigation measures applicable to all Nano laboratory levels

Measures applicable to all Nano laboratory levels		
Transport and elimination **(1)** of ENM	Conditioning of material contaminated by ENM	Toxic (trash bin for toxic)
		Double bag for toxic waste (100 microns thickness)
		Storage of bags in a sealed container
	Elimination of nanomaterials substances and products	Double packaging for both, solid and liquid waste
	Waste and PPE evacuation	Special waste treatment channel
	Transports of "nano-objects"	Double packaging **(2)**
Reception & shipping	Organization	Unique collecting point per building or chemical shop
	Procedure	Ordering procedure
		Delivery address
		Reception procedure
	Storage	Ventilated cupboard or ventilated storage room
Cleaning	How	Wet cleaning only
		"Asbestos" type vacuum cleaner
Pregnant woman	Work authorisation	Issued only by occupational physician

Comments:

(1) See **Annex 9** for details on waste management.

(2) Use a sealed container with secondary containment (closed box or sealed bag) when transporting a nanomaterial between laboratories or buildings.

Annex 6. Mitigation measures applicable to Nano 1 laboratories

Measures applicable to Nano 1 laboratories		
Technical	Ventilation	Chemistry lab type (renewal 5-10 X/h)
		Low pressure in the room
	Floor	Tile or resin flooring
Organisational	Access restriction	Regular lab access control
	Lab training	Basic training (laboratory practice) **(3)**
Personal	Eyes protection	Safety glasses
	Body protection	Lab coat
	Hands protection	1 pair of adapted long gloves **(4)**
Cleaning	Who ?	External personnel **(5)**
	Protective equipment	Regular
Audit & follow-up	Audit	Safety officer

Comments:

(3) Basic training consists of basic laboratory practice with the introduction to notions of the potential hazards and precautions of nanomaterials.

(4) Select gloves based on compatibility with materials and solvents to be used.

(5) External personnel are regular cleaning staff at the EPFL. Trained external personnel are regular cleaning staff to whom laboratory specific instructions/ explanations are given.

Annex 7. Mitigation measures applicable to Nano 2 laboratories

Measures applicable to Nano 2 laboratories		
Technical	Ventilation	Chemistry lab type (renewal without recycling 5-10 X/h)
		With at least sealed H14 filter for exiting air. Regular maintenance of the filter.
		Low pressure (15-20 Pa) in the room
		Capture at source **(6)**
	Floor	Resin flooring
	Manipulation under fume hood **(6)**	Compulsory / Filtered exhaust H14
Organisational	Restricted access	Control access system (authorized persons only)
	Lab training	Written working procedures
		Basic training (laboratory practice) **(3)**
		Continuous training (nano manipulation) **(3)**
Personal	Eyes protection	Safety glasses
	Body protection	Non-woven lab coat
		Overshoes
	Hands protection	1 pair of adapted long gloves **(4)**
Cleaning	Who	Trained external personnel **(5)**
	Protective equipment	The same as for laboratory personnel
	Supervision	Laboratory responsible
Audit & follow-up	Audit	MSST specialist
	Medical survey **(7)**	Only regular lab personal

Comments:

(3) Basic training consists of basic laboratory practice with the introduction to notions of the potential hazards and precautions for nanomaterials. Continuous training must address lab specific training relevant to nanomaterials and associated hazardous chemicals used in the processes/experiments. This latter can include the review of Safety Data Sheets if available and working procedures. The heads of laboratories or safety coordinators can dispense both training programmes.

(4) Select gloves based on compatibility with materials and solvents to be used.

(5) External personnel are regular cleaning staff at the EPFL. Trained external personnel are regular cleaning staff to whom laboratory specific instructions/ explanations are given.

(6) Depending on the type of the process/activity, capture at source or manipulation under fume hood will be necessary.

(7) A preventive medical examination (with a five year interval) is mandatory for everyone who:

1) Works in areas classified Nano 2 and Nano 3.
2) Has an annual duration of exposure of more than 30 days or 200 hours.

If you satisfy these two criteria, please send an email to: sante@epfl.ch. Please specify the type and class of nanomaterial and the duration of exposure.

The occupational physician will schedule an appointment for a medical examination at the EPFL Health Point. The examination includes: a targeted medical history, a physical examination, laboratory testing (haematology, renal and hepatic parameters and urinary status), spirometry and an electrocardiogram. Depending on your occupation, a chest X-ray may also be required. You will be directed to an external service provider for this X-ray.

Annex 8. Mitigation measures applicable to Nano 3 laboratories

Measures applicable to Nano 3 laboratories		
Technical	Ventilation	Chemistry lab type (renewal 5-10 X/h)
		With at least sealed H14 filter for exiting air. Regular maintenance of the filter.
		Low pressure (15-20 Pa) in the room
		Capture at source **(6)**
	Floor	Resin flooring
	Manipulation under fume hood **(6)**	Compulsory / Filtered exhaust H14
	SAS entrance and exit	SAS with overpressure vs corridor and lab **(8)**
		Safety shower (emergency) with collected drain
	Research installations	Set-ups will be enclosed or ventilated whenever feasible
Organisational	Restricted access	Control access system (authorised persons only)
		Evidence about exposed people + board to record presence.
		Only nano activities are allowed in the laboratory
	Lab training	Written working procedures
		Basic training (laboratory practice) **(3)**
		Continuous training (nano manipulation) **(3)**
	City/laboratory clothes separation	Compulsory
Personal	Eye protection	Laboratory mask or close fitting safety goggles
	Respiratory organs protection	Mask with assisted ventilation if handling duration > 2 h
		FFP3 mask if handling duration < 2 h
	Body protection	Overall with hood - Tyvek® style
		Overshoes and sticky mat
	Hands protection	2 pairs of adapted long gloves **(4)**
Cleaning	Who	Only laboratory personnel
	Protective equipment	The same as for laboratory personnel
Audit & follow-up	Formal lab audit	MSST specialist
	Medical survey	All persons manipulating NP

Comments:

3) Basic training consists of basic laboratory practice with the introduction to notions of the potential hazards and precautions of nanomaterials. Continuous training should address lab specific training relevant to the nanomaterial and associated chemicals used in the processes/experiments. This latter can include the review of Safety Data Sheets if available and working procedures. The heads of laboratories or safety coordinators can dispense both training programmes.

(4) Select gloves based on compatibility with materials and solvents to be used.

(5) Depending on the type of the process/activity, capture at source or manipulation under fume hood will be necessary.

(6) A preventive medical examination (with a five year interval) is mandatory for everyone who:

1) Works in areas classified Nano 2 and Nano 3.
2) Has an annual duration of exposure of more than 30 days or 200 hours.

If you satisfy these two criteria, please send an email to: sante@epfl.ch. Please specify the type and class of nanomaterial and the duration of exposure.

The occupational physician will schedule an appointment for a medical examination at the EPFL Health Point. The examination includes: a targeted medical history, a physical examination, laboratory testing (haematology, renal and hepatic parameters and urinary status), spirometry and an electrocardiogram. Depending on your occupation, a chest X-ray may also be required. You will be directed to an external service provider for this X-ray.

(7) SAS will be an area that is physically separated from the laboratory where city clothes can be changed into laboratory clothes, preventing contamination of the former.

Annex 9. Waste management

For waste labelling, refer to the tree for management of chemical waste, which can be found at the following website: http://scc.epfl.ch/chemical-waste

Regarding waste disposal, respect the following procedures:

- Contaminated material: to be disposed of in the plastic bags for toxics, inside metallic bins for toxics (picture below, left hand side). For more details, please refer to the website on waste containing ENM (https://www.epfl.ch/campus/security-safety/en/lab-safety/waste/nanomaterial-waste/);

- Solid waste: to be disposed of in adequate containers, one family of solids per recipient. Mark names of the substances or mixtures;

- Liquid waste: to be disposed of in plastic containers, one type of solvent per recipient. Mark name of the substance or the mixture.

Regarding waste conditioning for transport to the chemical store, use double packaging such as a secondary container with anti-shock or a sealable or tied plastic bag (picture below, right hand side).