Nanotechnology and Tyres

Risk Assessment Framework

BEST PRACTICES

OECD
BETTER POLICIES FOR BETTER LIVES

Best Practices on Health and Environment

Nanotechnology and Tyres: Elements for a Risk Assessment Framework

This publication is available electronically, at no charge.

For this and many other Environment, Health and Safety publications, consult the OECD's World Wide Web site (www.oecd.org/chemicalsafety/)

or contact:

OECD Environment Directorate,
Environment, Health and Safety Division
2 rue André-Pascal
75775 Paris Cedex 16
France

Fax: (33-1) 44 30 61 80

E-mail: ehscont@oecd.org

IOMC

INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

A cooperative agreement among FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD

Environment Directorate
ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT
Paris 2015

Acknowledgments

The OECD is grateful to the Tire Industry Project (TIP) of the World Business Council for Sustainable Development (WBCSD) for their contribution to this work.

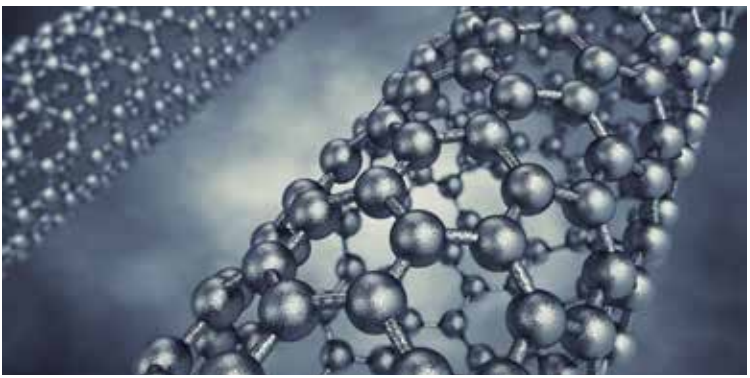


Photo credits
Cover page: © Noradoa/Shutterstock.com
Page 2 : © nobeastsofierce/Shutterstock.com
Page 4: ©ArchMan/Shutterstock.com
Page 9: © sakkmesterke/Shutterstock.com
Page 12: nobeastsofierce/Shutterstock.com
Page 15 : © bikeriderlondon/Shutterstock.com
Page 18 : © turbo83/Shutterstock.com
Page 21 : © Anna Vaczi/Shutterstock.com
Page 23: © Caplio R2 User
Page 25: © Efaman/Shutterstock
Page 32 : © Zeljko Radojko/Shutterstock.com

TABLE OF CONTENTS

INTRODUCTION

This Risk Assessment Framework (RAF) for Nanotechnology and Tyres provides guidance to develop company-specific risk assessments and/or risk management strategies for using nanomaterials as additives in tyres.

Despite the focus on tyres and the use of nanomaterials, it is likely that this RAF may provide useful lessons for various types of manufacturing settings. It could also be applicable to other types of "difficult substances" which are less understood in terms of their potential hazards.

Objective:

The best practices outlined in this Risk Assessment Framework (RAF) aim to provide a method for evaluating the potential human health and environmental concerns associated with the entire life cycle of nanomaterials used in tyres, focusing on the tyre manufacturing process. The life cycle of tyres includes the manufacture of tyres, mounting tyres on vehicles, the use of tyres on vehicles and the end-of-life of tyres.

They aim to allow the user of a new nanomaterial to evaluate the associated risks and to make decisions for minimising those risks. This general methodology has been developed as guidance for stakeholders to proactively minimise potential concerns for any nanomaterial of interest that is under development.

The elements in this manual are extracted from the **OECD report on Nanotechnology and Tyres: Greening Industry and Transport (2015)**.

METHODOLOGY:

The present framework focuses initially on a **qualitative approach** to assessing and managing risk in occupational settings called the **risk/control banding** approach.

It follows the guidance presented in the International Organization for Standardization (ISO) document "Nanotechnologies – Guidelines for Occupational Risk Management Applied to Engineered Nanomaterials – Part 2: The use of the Control Banding Approach in Occupational Risk Management" (ISO, 2012), and covers these steps:

- assign a hazard band ranking based on quantitative toxicological data or qualitative health hazard indicators (which are based on toxicity data)

- assign an exposure band based on a description of processes and physical forms of the nanomaterials.

To cover other life cycle stages, this framework expands beyond the risk/control banding approach used for the manufacturing phase. The general approach is:

- Use of the risk/control-banding approach to assess or manage human health risks from nanomaterials in occupational settings, particularly the manufacture of nanomaterials and processing of these materials for the manufacture of tyres.

- Evaluate the exposure to the general population and the environment over the life-cycle to assess the potential risk from nanomaterials.

Notes:

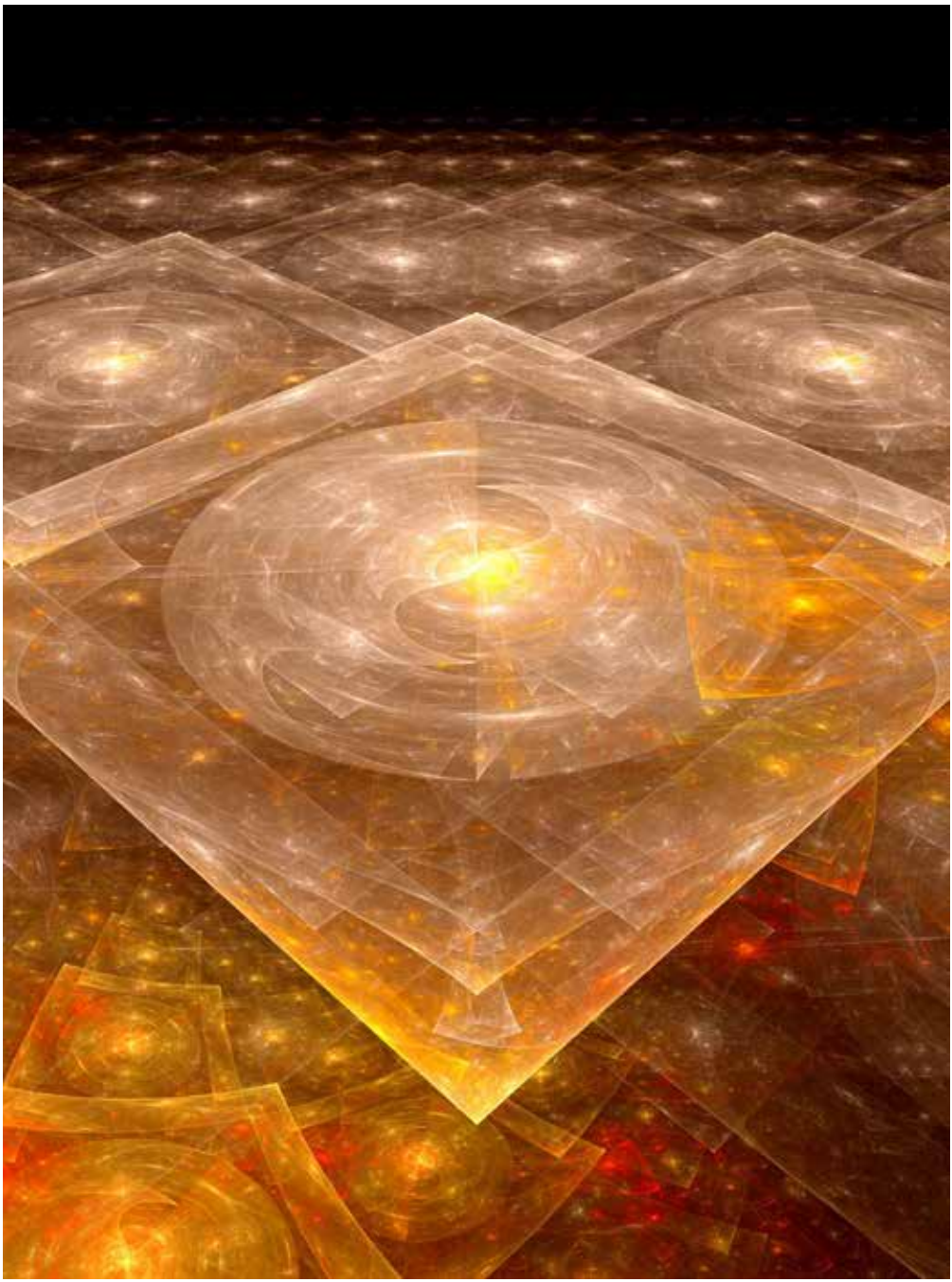
- For non occupational settings, the framework recommends an exposure pathway evaluation.

- This guidance can change as research reveals new findings and experts reach consensus on methods and protocols. Therefore, this framework specifically includes steps for continued revision and improvement based on future site-specific and/or general evaluations that improve the state-of-the-science and knowledge pertaining to the use of nanomaterials.

- Although this framework focuses on qualitative risk/control banding, it also addresses issues related to quantitative risk assessment. If adequate data are available, a quantitative risk assessment can be used to assess risk over the entire life cycle of nanomaterials used in tyres. However, this framework is not intended to provide guidance on quantitative risk assessments. Expertise on risk assessment and toxicology should be sought if a quantitative risk assessment is desired.

The life-cycle of a tyre includes several steps before reaching the final step (recycling or disposal), as described in figure 1. These steps are important to be considered in the risk assessment / risk management strategies.

Figure 1: The life-cycle of a tyre

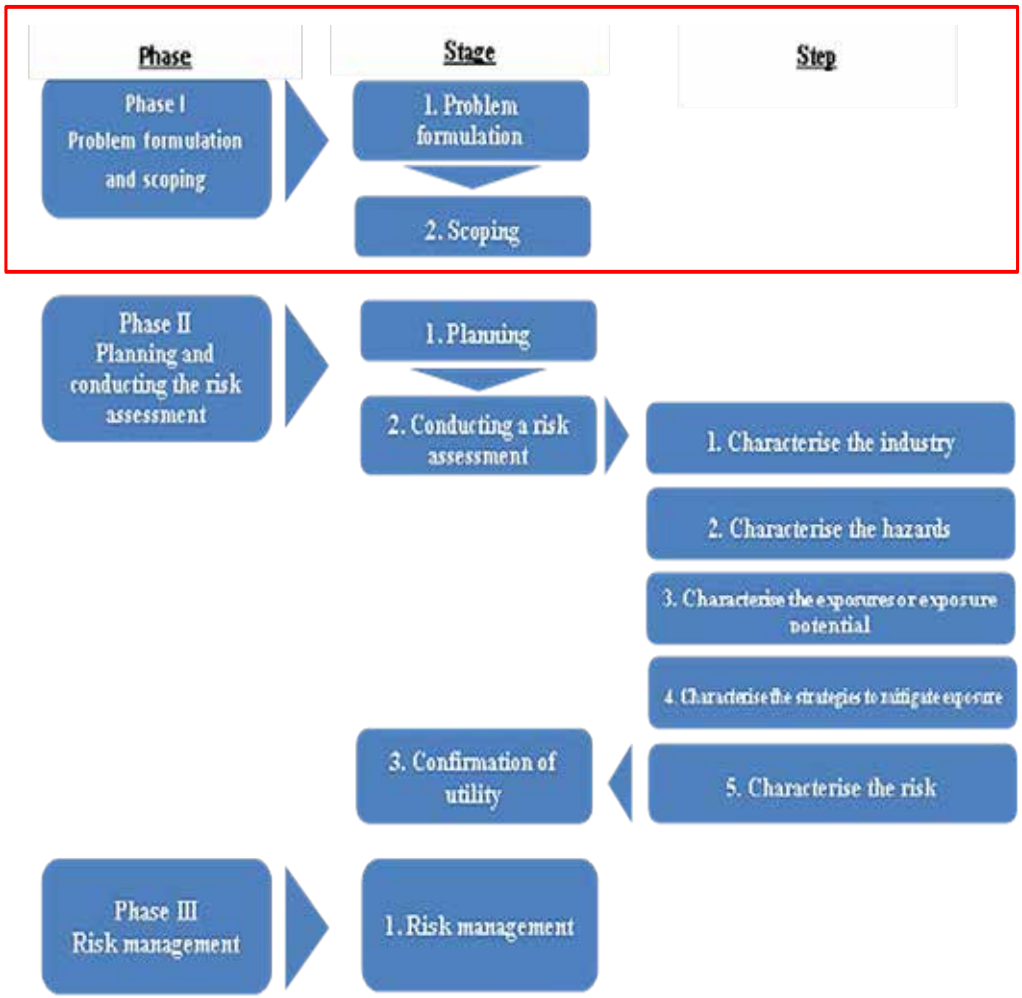


FRAMEWORK STEPS AND ILLUSTRATIVE EXAMPLES

The Risk Assessment Framework covers three steps:

1. **Phase I – Problem formulation and scoping;**
2. **Phase II – Planning and conducting the risk assessment; and**
3. **Phase III – Risk management.**

Figure 2: The organisation and the flow of the RAF.



PHASE I – PROBLEM FORMULATION AND SCOPING

1. Problem formulation

The *problem formulation* which is the first stage of phase I can be addressed considering the following questions:

Questions to be asked	Answers
1. Who is potentially at risk?	- workers who manufacture the nanomaterial of interest; - Workers who process the nanomaterials for manufacturing tyres - workers who mount, repair and/or balance nano-enabled tyres on vehicles; - workers involved with nano-enabled tyre recycling and/or disposal; - consumers who mount nano-enabled tyres on vehicles - the general population; - key ecological endpoints.
2. What are they at risk from?	Hazards associated with nanomaterials used in tyres.
3. Will this be a retroactive risk assessment or a proactive risk management strategy?	The user should decide if this framework will be used to conduct a retroactive risk assessment for an existing facility or operation or, alternatively, to develop a proactive risk management strategy.
4. What risk assessment output types are desired?	Alternatively are quantitative results desired? If quantitative results are desired, will they be deterministic or probabilistic? Deterministic risk assessments provide a single point estimate of risk at a site of concern, while probabilistic risk assessment methods generate a range of values from probability distribution functions. Is a qualitative risk-banding approach sufficient?

2. Problem scoping:

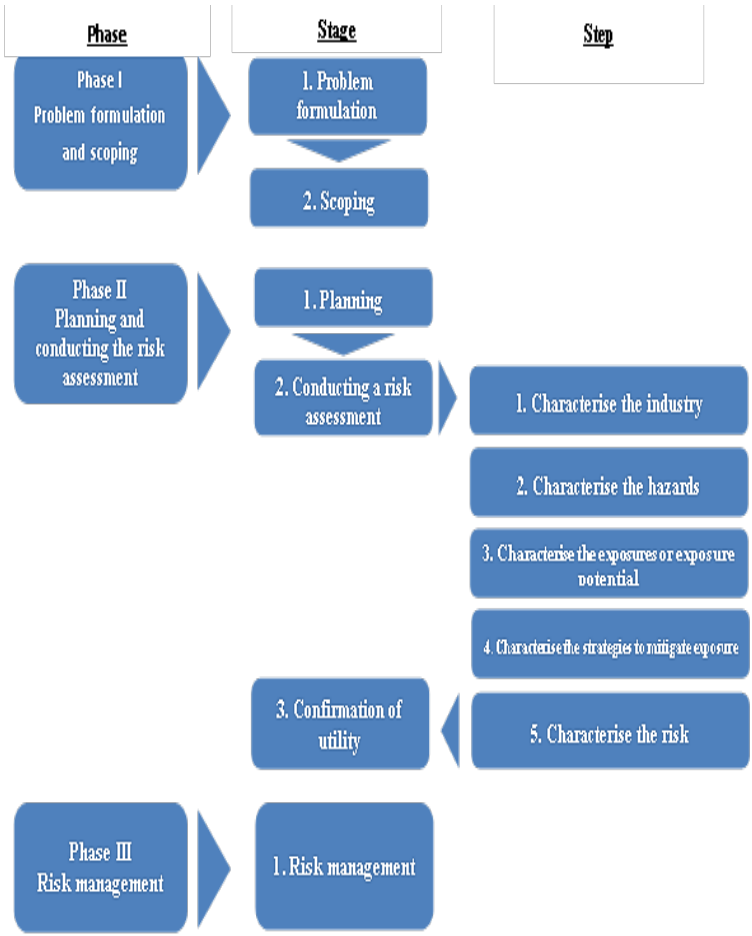
The proposed risk assessment framework is specific to the life cycle of a nanomaterial of interest used in tyres. For the purposes of this framework, this includes:

- manufacture of the nanomaterial being evaluated
- manufacture of tyres containing the nanomaterial
- use of the nano-enabled tyres
- end-of-life of the nano-enabled tyres.

PHASE II – PLANNING AND CONDUCTING THE RISK ASSESSMENT

Phase II consists of planning and then conducting the risk assessment. This phase is divided into three stages:

- *Stage 1. Planning for the risk assessment,*
- *Stage 2. Conducting the risk assessment, and*
- *Stage 3. Confirmation of the utility of the risk assessment.*



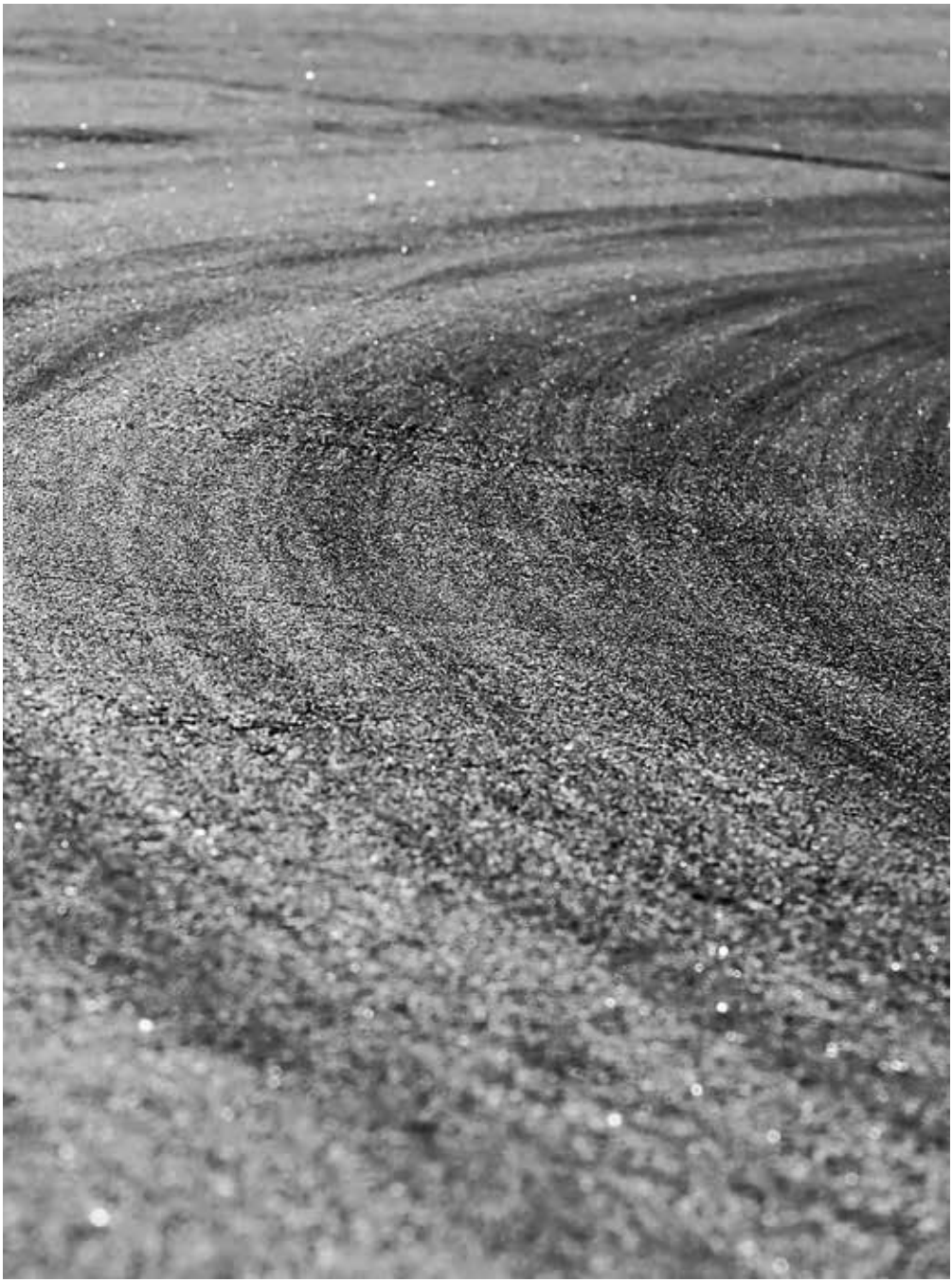
The following information is important when conducting a risk assessment of a nanomaterial:

- characterisation and physical/chemical properties
- toxicity
- exposure

Table 1. Planning for the risk assessment – Phase II

Characterisation and physical/chemical properties	- Data to identify the nanomaterial (nanomaterial name, CAS number, structural formula and molecular structure, composition of nanomaterial, basic morphology, description of surface chemistry, method of production) - Characterisation and physical/chemical properties: - melting point - relative density - flammability - solubility & dispersibility (in water or other biologically relevant fluids) - other relevant dispersibility data (e.g. zeta potential, isoelectric point) - partition coefficient (n-octanol/water) - physical state at standard conditions - crystalline phase - crystallite size - dustiness - representative transmission electron microscopy (TEM) images - aggregation and agglomeration potential - particle size distribution - specific surface area - surface chemistry - catalytic or photocatalytic activity - pour density - porosity - reduction/oxidation potential - radical formation potential

Toxicity	- pharmacokinetics (absorption, distribution, metabolism, elimination) - acute toxicity - repeated dose toxicity - chronic toxicity - reproductive toxicity - developmental toxicity - genetic toxicity - dose-response - experience with human exposure - epidemiological data - environmental fate and transport - bioaccumulation
Exposure	- physical form of the nanomaterial - amount of nanomaterial handled or processed - description of how the nanomaterial is handled or processed - duration (time per day) and frequency (occurrences per year) workers or members of the general population are potentially exposed to nanomaterials - determination of the potential for dust generation during the processes and worker activities - description of worker activities - actual exposure measurement results - identification of potential release sources - amount of nanomaterial released into the environment (per event or period such as per day or per year, and the frequency of release events such as per year
Data availability: Planning should also include a data gap analysis to determine what data needs remain	- Will testing be performed to satisfy data gaps? - In lieu of data for the nanomaterial being evaluated, is it appropriate to use surrogate data? Are surrogate data available? How will the surrogate data be used? What are the uncertainties associated with use of the surrogate data? For example, will the risk assessment use toxicity or exposure data of the bulk (macro-scale) version of the nanomaterial? Will the risk assessment use toxicity or exposure data of a similar nanomaterial? If surrogate data are used, how will they be evaluated to determine their appropriateness for the nanomaterial of interest? - In lieu of data for this nanomaterial, is it appropriate to use extrapolation or modelling techniques to characterise hazards or exposures? - How will the risk assessment results be evaluated to account for uncertainties introduced by the use of surrogate data or extrapolation or modelling techniques?



PHASE II, STAGE 2 - CONDUCTING THE RISK ASSESSMENT

For conducting the risk assessment, 6 steps must be followed:

- ### Step 1 – Characterise the industry

Tyre manufacturing, mounting tyres on vehicles, use of tyres on vehicles, end-of-life of tyres (recycling or disposal)

- ### Step 2 – Characterise the hazards

This is a summary of recommendations based on the hazard banding approach as discussed in ISO (2012) (Table 2). This approach can use either **quantitative toxicological data or qualitative health hazard indicators** to assign the hazard band ranking.

Table 2. Toxicological data used to characterise health hazard indicators

Human health: toxicological data can be used to describe the following human health hazard indicators
· Acute toxicity (Acute Tox.)
· Skin irritation/corrosion (Skin Irrit./Skin Corr.)
· Serious eye damage/eye irritation (Eye Dam./Eye Irrit.)
· Respiratory or skin sensitisation (Resp. or Skin Sens.)
· Mutations in germ cells (Muta.)
· Cancer (Carc.)
· Reproductive toxicity (Repr.)
· Experience with human exposure
· Epidemiological data
· Systemic Target Organ Toxicity – Single Exposure (STOT-SE
· Systemic Target Organ Toxicity – Repeated Exposure (STOT-RE)
· Aspiration hazard (Asp. Tox.)

Step 3 – Characterise the exposures or exposure potential

Given the level of uncertainty in work-related potential health risks from nanomaterials, control banding can be particularly useful for the risk assessment and management of nanomaterials for occupational settings. It can be used for risk control management in both a proactive and retroactive manner. In a proactive manner, potential risks are evaluated without the consideration of control measures.

A risk management plan can then be implemented and control measures can be selected. In a retroactive manner, the risk of a current process is assessed with consideration of existing control measures. The risk assessment can be used to evaluate the adequacy of the existing control measures.

Exposures or **potential exposure** should be characterised for complete exposure pathways. The United States Agency for Toxic Substances & Disease Registry (ATSDR) defines an exposure pathway as:

> The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing or touching); and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway. (ATSDR, 2009)

Exposure routes can be **inhalation, dermal or ingestion**. Exposure pathways should be characterised for each receptor population, as defined during problem formulation, for each life-cycle stage, in addition to workers who process nanomaterials for manufacturing tyres, they are:

- **workers who manufacture the nanomaterial of interest**
- **workers who mount, repair and/or balance nano-enabled tyres on vehicles**
- **workers involved with nano-enabled tyre recycling and/or disposal**
- **consumers who mount nano-enabled tyres on vehicles**
- **the general population**
- **key ecological endpoints**

Table 3. Health Hazard category allocation

Table 3 health hazard category allocation

Toxicological result or health hazard indicator	Category A	Category B	Category C	Category D	Category E
OEL dust (mg/m³) (8-hr TWA)	1-10	0.1-1	0.01-0.1	< 0.01	–
Acute toxicity	Low	Acute tox 4	Acute tox 3	Acute tox 1-2	–
LD50 oral route (mg/kg)	> 2 000	300-2 000	50-300	< 50	–
LD50 dermal route (mg/kg)	> 2 000	1 000-2 000	200-1 000	< 200	–
LC50 inhalation 4H (mg/L) aerosols/particles	> 5	1-5	0.5-1	< 0.5	–
Severity of acute (life-threatening) effects	–	STOT SE 2-3 Asp. Tox 1	STOT SE 1	–	–
Adverse effects per oral route (mg/kg) (single exposure)	–	Adverse effects seen ≤ 2 000	Adverse effects seen ≤ 300	–	–
Adverse effects per dermal route (mg/kg) (single exposure)	–	Adverse effects seen ≤ 2 000	Adverse effects seen ≤ 1 000	–	–
Sensitisation	Negative	Slight cutaneous allergic reactions	Moderate-strong cutaneous allergic reactions	–	Prevalent moderate to strong respiratory allergic reactions Resp. Sens. 1
Mutagenicity/genotoxicity	Negative	Negative	Negative	Negative	Mutagenic in most relevant *in vivo* and *in vitro* assays Muta 2 Muta 1A – 1B
Irritant/corrosiveness	None to irritant Eye Irrit. 2, Skin Irrit. 2 EUH 066	–	Severe irritant to skin/eyes Irritant to respiratory tract STOT SE 3 Eye Dam. 1 Corrosive Skin Corr. 1A – 1B	–	–
Carcinogenicity	Negative	Negative	Some evidence in animals Carc. 2	–	Confirmed in animals or humans Carc. 1A – 1B
Developmental/reproductive toxicity	Negative	Negative	Negative	Reprotoxic defects in animals and/or suspected or proven in humans Repr. 1A, 1B, 2	–

Table 4. Health Hazard category allocation (cont.)

Table 4 Health hazard category allocation (*cont.*)

Toxicological result or health hazard indicator	Category A	Category B	Category C	Category D	Category E
Likelihood of chronic effects (e.g. systemic)	Unlikely	Unlikely	Possible STOT RE 2	Probable STOT RE 2	–
Adverse effects per oral route (mg/kg-day) (90-day chronic study)	–	–	Adverse effects seen ≤ 100	Adverse effects seen ≤ 10	–
Adverse effects per dermal route (mg/kg-day) (90-day chronic study)	–	–	Adverse effects seen ≤ 200	Adverse effects seen ≤ 20	–
Ill/occupational health experience	No evidence of adverse health effects	Low evidence of health effects	Probably evidence of adverse health effects	High evidence of adverse health effects	High evidence of severe adverse health effects

Source: International Organization for Standardization (ISO) (2012). *Nanotechnologies – Guidelines for Occupational Risk Management Applied to Engineered Nanomaterials – Part 2: The Use of the Control Banding Approach in Occupational Risk Management*. ISO TC 229/WG N.

There are four potential exposure bands (from the lowest exposure EB 1 to the highest potential exposure EB4). This is depending on the physical form of the nanomaterial. When using a new nanomaterial, the highest potential exposure EB4 is when the nanomaterial is a dusty material and the lower EB1 is when the nanomaterial is dispersed in a solid matrix.

Guidance for identifying potential exposure bands is given in details in the tables 4, 5, 6, 7, 8, 9, Chapter 5, Nanotechnology and Tyres: Greening Industry and Transport, OECD (2014).

Step 4 – Characterise the strategies or techniques to mitigate exposure

Exposure control measures that are, or can be, implemented in the workplace should be identified. They can lower exposures by reducing emission (the release of nanomaterials from a source), transmission (the transport of nanomaterials from an emission source to a worker) and immission (the introduction of nanomaterials into a worker).

All the control technologies should be 1) evaluated for their removal or capture efficiency of nanomaterials, and 2) adapted to the industry practices.

Practical example:

- The reduction of nanomaterial emission from the source can be achieved through work practice controls such as handling nanomaterials in suspension into a liquid or, dispersed into a paste or a solid matrix rather than in the form of dry powders. Handling nanomaterials in these physical forms is likely to reduce fugitive dust emissions. It is also recommended to avoid high thermal or mechanical energy processes or other activities that are likely to release nanomaterials from their matrix.

- Engineering controls to reduce the transmission from the source to the workers (tyre manufacturing operations): There are two generic transmission control measures:

i) local control, e.g. containment and/or local exhaust ventilation; and
ii) general ventilation, e.g. natural or mechanical ventilation.

There are three generic immission reduction measures:

i) personal enclosure/separating the worker from the source, e.g. a ventilated cabin;

ii) segregation of the source from the worker, i.e. isolation of sources from the work environment in a separate room without direct containment of the source itself;

iii) use of Personal Protective Equipment PPE. Use of PPE is usually the last resort in exposure reduction.

- Engineering controls to prevent the release of nanomaterials into the environment: air pollution control devices on stack air vents and incinerators that combust nanomaterial-containing wastes ➡ removing particulates from gaseous waste streams can include filter bags, wet and dry electrostatic precipitators, cyclones and scrubbers.

- Administrative controls:

i) handling all wastes that contain, or may potentially contain, nanomaterials as hazardous waste.

ii) treating nanomaterial-containing wastewater as hazardous waste and avoiding the discharge of any nanomaterials to wastewater treatment.

Step 5 – Characterise the risk.

a) Control Banding: Hazard

The method for characterizing a hazard is modelled after the ISO 12901-2 standard which is called the "control banding" approach. The OECD "Nanotechnology and Tyres" report contains a table for health hazard category allocation with five categories: from no significant hazard A to severe hazard B. Each nanomaterial will be classified in one of these categories based on available information on their hazards. This classification can be provided by the producer of the new nanomaterial using the best available knowledge with the support of the user (Table 2).

b) Control Banding: Exposure

There are two parts, one that applies to the producer of the nanomaterial, and the other that applies to the tyre manufacturer who will use the nanomaterials. There are four potential exposure bands, from lowest potential exposure EB1 to highest potential exposure EB4. These banding assignments will depend on the physical form of the nanomaterial.

> **Example:**
> A nanomaterial with the highest potential exposure EB4 would be a nanomaterial in a dusty form and the lowest potential exposure EB1 is when the nanomaterial would be embedded in a solid matrix.

c) Control banding: The Matrix

The matrix below is the Control Banding Matrix (ISO 12901-2).

Table 5. Control Banding Matrix

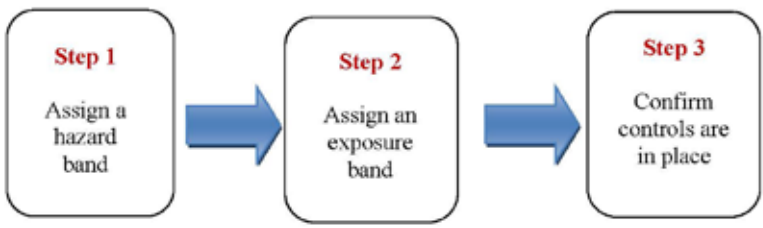
	Exposure Band				
		EB1	EB2	EB3	EB4
	A	CB1	CB1	CB1	CB2
	B	CB1	CB1	CB2	CB3
Hazard Band	C	CB2	CB3	CB3	CB4
	D	CB3	CB4	CB4	CB5
	E	CB4	CB5	CB5	CB5

The control bands are defined in ISO (12901-2) and are correlating to specific control strategies as follows:

- CB1: natural or mechanical general ventilation;
- CB2: local ventilation: extractor hood, slot hood, arm hood, table hood, etc.;
- CB3: enclosed ventilation: ventilated booth, fume hood, closed reactor with regular opening;
- CB4: full containment: glove box/bags, continuously closed systems; and
- CB5: full containment and review by a specialist: seek expert advice.

Evaluating risk first requires one to assign a hazard band, then assign an exposure band and then confirm the appropriate controls are in place (see Table 5 and Figure 3).

Figure 3. Control banding for risk evaluation



d) Limits of Control Banding:

The control banding approach is currently only applicable for assessing exposure potential for workers who directly handle the new nanomaterials in occupational settings. The control banding approach is not applicable for assessing exposure potential for consumers, the general population, or ecological impacts. Given this limitation in the ISO 12901-2 standard, the OECD framework presents additional guidance.

e) Environmental release during the use of tyres:

Nanomaterials can be released to the environment from rubber particles wearing off or from blowouts. These mechanisms release vulcanised rubber that contains nanomaterials. The release of nanomaterials from the rubber depends on the properties of the nanomaterial and the degradation potential of the rubber in the environment. Table 6 presents guidance for identifying exposure pathways of nanomaterials during the use of tyres.

Table 6. Guidance for Identifying Exposure Pathways of Nanomaterials during the Use of Tyres

Potential Sources from Tyre Blowouts or Worn-off Particles	**Potential** Environmental Media and Transport Mechanism	**Point of Exposure**	**Route of Exposure**	Receptor Population
Vulcanised rubber particles or pieces laying on the ground	Degradation of rubber and leaching of nanomaterials onto soil or into groundwater or captured in storm water runoff to surface water and sediments	Soil, Groundwater, Surface water, or Sediment	N/A	Terrestrial Ecological Endpoints (e.g., plants); and Aquatic Eoclogical Endpoints (e.g., pelagic species, benthic species)
	Nanomaterials passing through drinking water treatment plant or getting into drinking water wells	Drinking water	Ingestion	General Population

f) Potential exposure from end-of-life tyres:

Key concepts to consider in analysing the exposure pathways of new nanomaterials from an incinerator or energy recovery system include, but are not limited to, the following:

- Oxidation or other reactions that occur in the combustion chamber (e.g., a carbon-based nanomaterial that is fully or partially oxidised; a fully oxidised metal nanomaterial that cannot further oxidise);

- Breakdown of larger, nanostructured, non-oxidisable nanomaterials into smaller particles; and

- Transport of nanomaterials, or nanomaterial combustion by-products, through an air pollution control device.

g) Additional considerations:

The qualitative risk/control banding approach of ISO 12901-2 focuses on industrial settings only.

ISO 12901-2 is based on global production and use of nanomaterials in tyres and can be applied to nanomaterials in other products.

Although this framework focuses on qualitative risk/control banding, it also addresses topics of a quantitative risk assessment. If adequate data are available, a quantitative risk assessment can be used to assess risk over the entire life cycle of the use of nanomaterials in tyres. However, this framework is not intended to provide guidance on quantitative risk assessments. Risk-assessor expertise should be sought if a quantitative risk assessment is desired.

PHASE II, Stage 3 – Confirmation of utility of risk assessment

To confirm the utility of a risk assessment, certain questions must be asked, including the following:

➤ Do the assessment results include the attributes called for in planning (were the criteria defined in the beginning of the assessment have been all considered)?

➤ Do the assessment results provide sufficient information to discriminate among risk management options?

➤ Has the assessment been satisfactorily reviewed by others?

Note:

If the utility of the risk assessment cannot be confirmed, then the planning stage must be re-visited to evaluate what is necessary to appropriately characterise the risks. The level of uncertainty and variability must also be re-evaluated to determine if the risk results can be reported within an acceptable level of confidence. If confirmation of utility can be achieved, then Phase III of the framework (risk management) can begin.

PHASE III – RISK MANAGEMENT

The purpose of risk management is to reduce risks to an appropriate level and the process should follow the control hierarchy demonstrated by the **STOP principle** (as described in ISO [2012]) and the United States Occupational Safety and Health Administration's (OSHA) hazard prevention and control guidance (OSHA, 2013).

The STOP principle (substitution, technical measures, organisational measures, and personal protective equipment) and OSHA's hazard prevention and control guidance both follow the same hierarchy of:

1) attempting to remove a hazard through design or redesign of industrial processes;

2) trying to minimise exposure to a hazard through controls and management practices; and

3) protecting workers against any remaining exposure to the hazard.
The risk management plan and the key points related to worker health within occupational settings, as well as to the general population and ecological endpoints are summarised in the table opposite:

Risk management plan	1. Substitution: if the nanomaterial presents hazard concerns, determine if it can be substituted with a less hazardous material. 2. Process design: design the process such that exposures are minimised (e.g. enclosed process, using automation in place of manual activities). 3. Engineering controls: implement engineering controls to minimise exposures (e.g. barriers, local ventilation). 4. Safe work practices: implement company- or site-specific workplace rules to ensure workers take necessary precautions to minimise exposures (e.g. respiratory protection standards, laboratory chemical hygiene standards, protocols for cleaning spilled nanomaterials and fixing leaks). 5. Personal protective equipment: require the use of proper PPE to minimise exposures that remain after all of the above considerations. Include proper PPE training. 6. Systems to track hazard correction: develop a hazard tracking system to track the original discovery of a hazard to its correction. 7. Preventive maintenance systems: implement good scheduling and documentation of maintenance activities. For example, good maintenance scheduling of pressurised pneumatic transfer lines can prevent leaks, instead of relying on visual inspection of leaks before maintenance occurs. 8. Medical programmes and industrial hygiene monitoring: implement industrial hygiene monitoring programmes to regularly monitor exposures. Implement a medical programme to record and document employee health complaints and injuries.
Key points	1. Avoid any discharge of nanomaterials to wastewater. 2. Treat nanomaterials and any wastes potentially containing nanomaterials as hazardous waste. 3. Where possible, handle nanomaterials in small quantities in controlled, laboratory settings. 4. Where possible, handle nanomaterials incorporated into a solid matrix instead of as a solid powder. For example, the laboratory incorporation of nanomaterials into rubber blocks for subsequent addition to the low-temperature mixer during tyre manufacturing could be considered a good practice, not only to minimise worker exposures, but also to reduce fugitive dust releases.

This publication is available electronically, at no charge.

For this and many other Environment, Health and Safety publications, consult the OECD's World Wide Web site (www.oecd.org/chemicalsafety/)

or contact:

OECD Environment Directorate,
Environment, Health and Safety Division
2 rue André-Pascal
75775 Paris Cedex 16
France

Fax: (33-1) 44 30 61 80

The best practices outlined in the Risk Assessment Framework (RAF) aim to provide a method for evaluating the potential human health and environmental concerns associated with the entire life cycle of nanomaterials used in tyres, focusing on the tyre manufacturing process. The life cycle of tyres includes the manufacture of tyres, mounting tyres on vehicles, the use of tyres on vehicles and the end-of-life of tyres.

The elements in this manual are extracted from the **OECD report on Nanotechnology and Tyres: Greening Industry and Transport (2015)**

www.oecd.org/chemicalsafety/nanosafety/nanotechnology-and-tyres-9789264209152-en.htm