The 5th International Conference on Health and Safety Issues Related to Nanomaterials, Nanosafe 2016

Control Banding, Nanomaterials Manufacturing, and Occupational Health and Safety—A Review

K. Dimou (MSc. Student) and C. Emond,

University of Montreal

Outline

1. Introduction and Problem Statement

- Health risk assessment (HRA) was first proposed by the National Research Council (NRC) in (1983). HRA follows 4 steps.

- In the case of ENMs, a quantitative health risk assessment (QHRA) is difficult, given an important uncertainties regarding the toxicity of nanomaterials.

- *A risk assessment method for controlling nanoparticle exposures remains mainly qualitative or semi-quantitative in nature. This method is known as "control banding (CB)," an alternative approach to QHRA.*

2. Objectives of the Research

- A brief literature review over the past 20 years that focuses on the CB approach and comparison of the main CB tools specifically developed for nanomaterials.

- Development of an original risk assessment method combining QHRA and CB based on characterization of physico-chemical and biological properties of nanomaterials.

3. Methodology: Literature Review

- In the 1980s, the pharmaceutical industry developed the CB approach for new products without toxicological data or occupational exposure limits (OELs).

- CB is a qualitative or semi-quantitative approach to risk assessment and risk management. CB consists of grouping the health hazards (risk bands), grouping the exposure potential (exposure bands), and then combining these elements to generate a set of controls (control bands).

3. Methodology: CB Example (Cornelissen R., IVAM Uva bv, nl)

Possibility of exposure to nanoparticles during a certain activity with NMP	Description of the hazard category for NMP		
	Hazard category 1: (water) soluble nanoparticles	***Hazard category 2:*** Synthetic, persistent nanomaterials (non-fibrous)	***Hazard category 3:*** Fibrous, non soluble nanomaterials for which asbestos like properties can not be ruled out
Exposure category I: Emission of free nanoparticles minimized due to working in full containment	**A**	**A**	**B**
Exposure category II: Emission of nanoparticles (1-100 nm) embedded in a larger solid or liquid matrix (100 nm - 100 µm) is possible	**A**	**B**	**C**
Exposure category III: Emission of primary nanoparticles (1-100 nm) is possible	**A**	**C**	**C**

Control level	Advised control measures
A : Low	Apply sufficient (room) ventilation, if needed local exhaust ventilation and/or containment of the emission source and use appropriate personal protective equipment.
B : Uncertain	According to the hierarchic Occupational Hygienic Strategy, the technical and organizational feasible protective measures are evaluated on their economical feasibility. Control measures will be based on this evaluation
C : High	The hierarchic Occupational Hygienic Strategy will be strictly applied and all protective measures that are both technically and organizationally feasible will be implemented.

3. Methodology: Literature Review (contd.)

- The approach was adapted by organizations, in particular, for small and medium-sized enterprises (SMEs) that may not have the benefit of a full-time occupational hygienist's expertise.
- The process is now used in many industries and in diverse applications around the globe and more recently, ENMs.
- Several CB–type tools have already been developed for nanomaterials.

3. Methodology: Literature Review (contd.)

CB is

- A system that makes use of previous knowledge
- Task-based advice
- Useful to SMEs
- Focused on controls

3. Methodology: Literature Review (contd.)

CB is not

- A replacement for professionals (i.e., Industrial Hygienists)
- A replacement for health surveillance or environmental samples
- The only and last step; additional follow up must be performed

4. Result: Literature Review Summary

- The CB Nanotool (Paik et al. [2008) **Lawrence Livermore National Laboratory USA**
  - http://controlbanding.net/Services.html
- The Swiss Precautionary Matrix (Höck et al., 2008) **Switzerland**
  - http://www.bag.admin.ch/nanotechnologie/12171/12174/14653/index.html?lang=en
- ANSES CB Nanotool (2010) **Anses France**
  - http://www.anses.fr/
- The NanoSafer CB tool (Jensen et al.; Kristensen et al., 2010), **Danish**
  - http://nanosafer.i-bar.dk/
- The IVAM Guidance (Cornelissen et al., 2011), **Dutch Social Partners**
  - http://www.industox.nl/Guidance on safe handling nanomats&products.pdf
- Stoffenmanager Nano (Van Duuren-Stuurman et al., 2012), **TNO and ArboUnie, Holland**
  - https://nano.stoffenmanager.nl/)

4. Results (contd.)

These CB–type tools for nanomaterials that were developed between 2008 and 2012 have already been reviewed for a comparative analysis:

- ✓ **Brouwer, 2012;**
- ✓ **Ligouri et al., 2016;**
- ✓ **Jiménez et al., 2016;**
- ✓ **Eastlake et al., 2016.**

4. Results (contd.)

- It is evident from the scope of each of the tools that they were developed for different purposes such as the following:
  - **CB Nanotool** was created to protect nanotechnology researchers.
  - **IVAM Guidance** was developed to support employers and employees in identifying the risks associated with different work situations.
  - **Stoffenmanager Nano, NanoSafer, and the ANSES tool** were developed for occupational risk assessment and management during synthesis and downstream use of nanomaterials, but also for laboratory work.
  - **Precautionary Matrix** was created for risk identification and prioritization, taking into consideration the workplace, consumers, and the environment from a life-cycle perspective.

4. Results (contd.)

- The first phase of this work was to develop an assessment tool of ENMs, based on the NRC's approach. (2015)
- *" Integrated Approach to Design and Safe Handling of Nanomaterials - A Program based on a Dialogue Between Industry and Evaluators of Health Risks "(published on IRSST's website).*

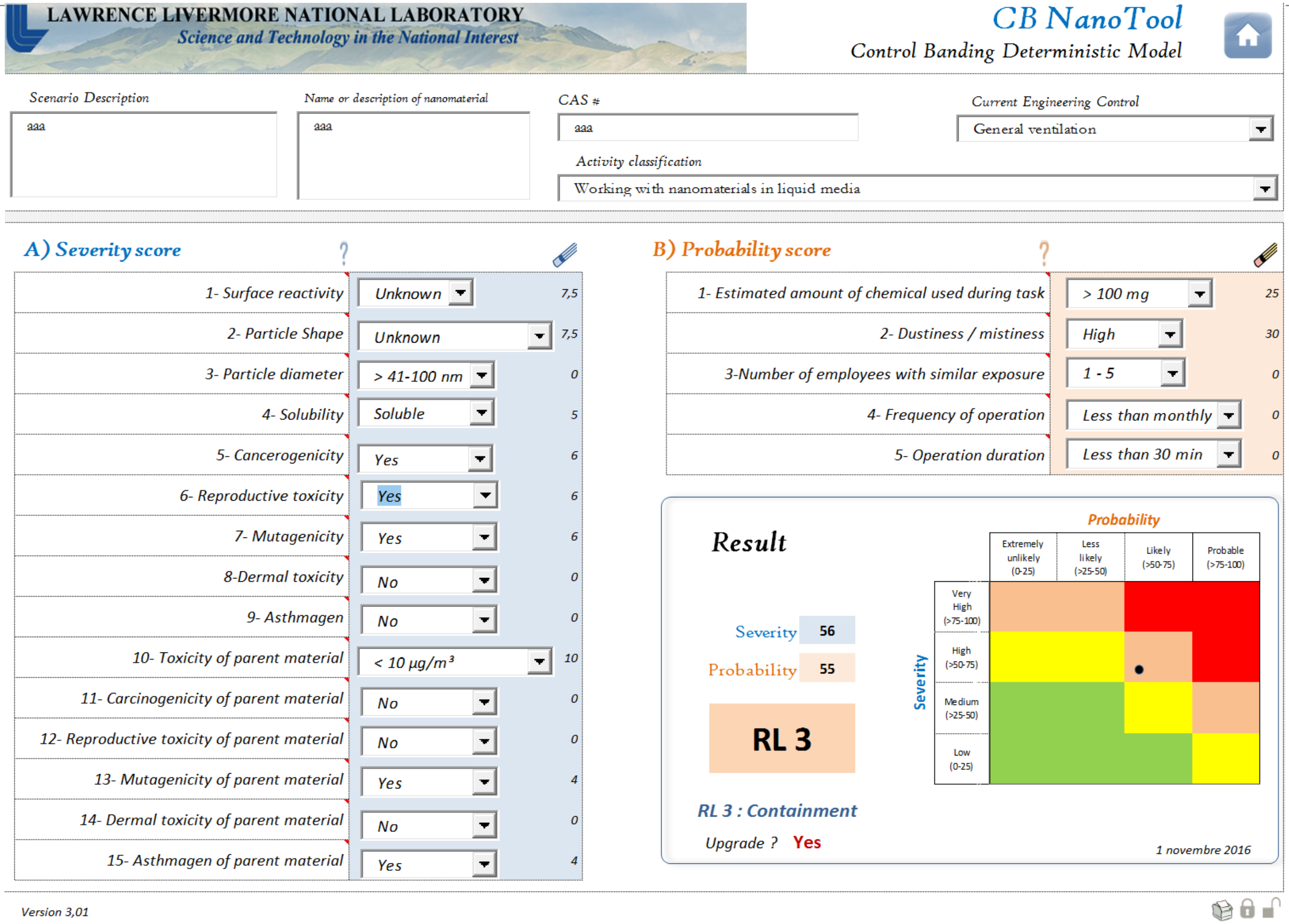
4. Results (contd.)

- This work, based on physico-chemical and biological characteristics, represents the second phase of this project.
- This phase is needed in order to select appropriate chemical and biological characterization tests in order to standardize the assessment tools developed.
- The most relevant parameters for the physico-chemical and biological characterizations of nanomaterials are selected.

4. Results: Assessment Tool of Nanomaterials Based on Physico-Chemical and Biological Characteristics (contd.)

Physicochemical / Biological	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5	TEST 6
TEST 1						
TEST 2						
TEST 3						
TEST 4						
TEST 5						
TEST 6						

4. Results: Step Forward CB-MC Here as an Example (contd.)



(Daniel Drolet retired from IRSST as a collaborator for this portion of project

5. Discussion

- The characterization of nanomaterials is a crucial step
- In this study, we were mainly interested in the characterization of ENMs to analyze this reactivity with biological materials.
- This method will contribute to a better understanding of nanomaterials to anticipate their potential effects on humans.

5. Discussion (contd.)

- This approach is different from that developed by other agencies that assess and characterize the risk for workers and the population.
- It was important to identify a minimum number of tests that could generate a maximum amount of information.
- The toxicology and physico-chemical tests that were selected are the most commonly used in the nanotechnology field.

6. Conclusions

- The proposed method of CB is original because it is dependent upon the structure of nanomaterials, but is not based on the exposure on the first intention.
- This CB, based on characterizations of the potential hazards posed by nanomaterials for a better guideline of the health implications and safe handling. From this independent hazardous assessment, it is possible to combine this assessment and the exposure assessment.

7. Acknowledgments

- BioSimulation Consulting Inc., Delaware, USA
- IRSST, Quebec, Canada
- University of Montreal, Montreal, Quebec, Canada
- Daniel Drolet (retired from IRSST)