Control Banding

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The International Labor Organization defines Control Banding as "a complementary approach to protecting worker health by focusing resources on exposure controls. Since it is not possible to assign a specific Occupational Exposure Limit to every chemical in use, a chemical is assigned to a 'band' for control measures, based on its hazard classification according to international criteria, the amount of chemical in use, and its volatility/dustiness."[1] The banding is then utilized to recommend four possible control strategies.

Below is an example of how control banding might be used with respect to nanomaterials:

Exposure Control

- Establish designated areas for Control Banding

  Examples: Entire laboratory or manufacturing area, or portion of the larger area, such as a laboratory hood or glove box

- Designated areas are posted with warning signs informing employees that they are entering a nanomaterial work area.
- Signs specify administrative controls and personal protective equipment (PPE) required for entry.
- Utilize following table to determine the overall risk level of the activity and the appropriate control strategies

Exposure Duration	Bound Materials	Potential Release	Free / Unbound
Hazard Group A (Known to be inert)			
Short	1	1	2
Medium	1	1	2
Long	1	2	2
Hazard Group B (Understand reactivity/function)			
Short	1	2	2
Medium	1	2	3
Long	1	3	3
Hazard Group C (Unknown Properties)			
Short	2	2	3
Medium	2	3	4
Long	2	4	4

Exposure Duration Key:
Short: < 4 hours/day, 2 days/week
Medium: 4 to 6 hours/day, 3 to 5 days/week
Long: 6 to >8 hours/day, 3 to 5 days/week

Release Key
Bound: Nanoparticles in Solid Matrix
Potential: Nanoparticles in friable or sol gel matrix
Free/Unbound: Nanoparticles unbound, not aggregated

Control Band (Risk Level) Key
1: General ventiliation and personal protective equipment ("PPE")
2: Engineering controls and/or respirators, additional PPE
3: Containment (e.g., glove box)
4: Seek specialist advice

Please see the following resources for more information about the utilization of control banding with respect to nanomaterials:

- Samuel Y. Paik and David M. Zalk (Lawrence Livermore National Laboratory) and Paul Swuste (Safety Science Group, Delft University of Technology), "Application of a Pilot Control Banding Tool for Risk Level Assessment and Control of Nanoparticle Exposures," The Annals of Occupational Hygiene (16 May 2008).
- Agence nationale de sécurité sanitare (France), "Development of a specific Control Banding Tool for Nanomaterials" (December 2010)
- Stoffenmanager 4.0 (Netherlands). The Stoffenmanager is a "tool for prioritizing worker health risks to dangerous substances"; "quantitative inhalation exposure tool"; "REACH Tier one quantitiative inhalation exposure tool."
- Workplace Health and Safety Queensland, Australia,"Nanomaterial Control Banding Tool Worksheet.

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1. International Labour Organization, SafeWork

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Control Banding Nanotool

SUMMARY INSTRUCTIONS FOR CB NANOTOOL 2.0

Severity Score: Sum of all severity factors. Maximum score is 100. Out of the 100 pts, 70 points are based on characteristics of the nanomaterial and 30 points are based on characteristics of the parent material. Thus, more weight is given to nanoscale characteristics. 0-25: Low severity, 26-50: Medium severity, 51-75: High severity, 76-100: Very high severity.

1. Surface reactivity – Surface chemistry is known to be a key factor influencing the toxicity of inhaled particles. Particle surface free radical activity is the primary factor that influences the material's overall surface reactivity. Points will be assigned based on a qualitative judgment of whether the surface reactivity is high, medium, or low. Research studies will be consulted, when available, to make the judgment. High: 10 pts, Medium: 5 pts, Low: 0 pts, Unknown: 7.5 pts.

2. Particle shape – Studies have shown that exposure to fibrous particles like asbestos have long been associated with increased risk of fibrosis and cancer. Tubular structures, like carbon nanotubes, have also been shown to cause inflammation and lesions in rat lungs. Based on this information, the highest severity score is given to fibrous or tubular-shaped particles. Particles with irregular shapes (other than tubular or fibrous) are given a medium severity score because they typically have higher surface areas relative to isotropic (e.g. compact or spherical) particles. Tubular or fibrous: 10 pts, Anisotropic: 5 pts, Compact or spherical: 0 pts, Unknown: 7.5 pts.

3. Particle diameter – based on the ICRP curve, particles in the 1-10 nm range have a greater than approximately 80% chance of depositing in the lungs. Particles in the 10-40 nm range have a greater than approximately 50% possibility of depositing in the lungs and particles in the 41-100 nm range have a greater than approximately 20% possibility of depositing in the lungs. Based on this ability to deposit in the lungs (regardless of the region of deposition) and the fact that smaller particles have a higher overall surface area compared to larger particles for a given mass concentration, the following points are assigned to a given particle size range and used to determine the severity score. 1-10 nm: 10 pts, 11-40 nm: 5 pts, <41-100 nm: 0 pts, Unknown: 7.5. pts.

4. Solubility – several studies have shown that poorly soluble inhaled nanoparticles can cause oxidative stress, leading to inflammation, fibrosis, or cancer. Since soluble nanoparticles can also cause adverse effects through dissolution in the blood, severity points are assigned to soluble nanoparticles as well, but to a lesser degree than for insoluble particles. Insoluble: 10 pts, Soluble: 5 pts, Unknown: 7.5 pts.

5. Carcinogenicity – points are assigned based on whether the nanomaterial is carcinogenic or not. Yes: 6 pts, No: 0 pts, Unknown: 4.5 pts.

6. Reproductive toxicity – points are assigned based on whether the nanomaterial is a reproductive hazard or not. Yes: 6 pts, No: 0 pts, Unknown: 4.5 pts.

7. Mutagenicity – points are assigned based on whether the nanomaterial is a mutagen or not. Yes: 6 pts, No: 0 pts, Unknown: 4.5 pts.
8. Dermal toxicity – points are assigned based on whether the nanomaterial is a dermal hazard or not. Yes: 6 pts, No: 0 pts, Unknown: 4.5 pts.

9. Asthmagen – points are assigned based on whether the nanomaterial is an asthmagen or not. Yes: 6 pts, No: 0 pts, Unknown: 4.5 pts.

10. Toxicity of parent material – the bulk material of some nanoparticles have established occupational exposure limits. While it is known that the toxicity of particles at the nanoscale can differ significantly from their larger counterparts, this provides a good starting point for understanding the toxicity of the material. Points are assigned according to the OEL (occupational exposure limit) band of the bulk material. < 10 µgm-3: 10 pts, 10 µgm-3– 100 µgm-3: 5 pts , 101 µgm-3 - 1 mgm-3: 2.5 pts, >1 mgm-3: 0 pts Unknown = 7.5 pts.

11. Carcinogenicity of parent material – points are assigned based on whether the parent material is carcinogenic or not. Yes: 4 pts, No: 0 pts, Unknown: 3 pts.

12. Reproductive toxicity of parent material – points are assigned based on whether the parent material is a reproductive hazard or not. Yes: 4 pts, No: 0 pts, Unknown: 3 pts.

13. Mutagenicity of parent material – points are assigned based on whether the parent material is a mutagen or not. Yes: 4 pts, No: 0 pts, Unknown: 3 pts.

14. Dermal toxicity of parent material – points are assigned based on whether the parent material is a dermal hazard or not. Yes: 4 pts, No: 0 pts, Unknown: 3 pts.

15. Asthmagen of parent material – points are assigned based on whether the parent material is an asthmagen or not. Yes: 4 pts, No: 0 pts, Unknown: 3 pts.

Probability Score: Sum of all exposure factors. Maximum score is 100. These factors determine the extent to which employees may be potentially exposed to nanoscale materials, primarily through inhalation, but also through dermal contact. 0-25: Extremely unlikely, 26-50: Less likely, 51-75: Likely, 76-100: Probable.

1. Estimated amount of chemical used during task. >100 mg: 25 pts, 11-100 mg: 12.5 pts, 0-10 mg: 6.25 pts, Unknown: 18.75 pts.

2. Dustiness/mistiness – points are assigned according to dustiness/mistiness level of material. Until further guidance is provided on quantifying dustiness/mistiness levels, points will assigned based on an estimate of relative dustiness/mistiness level. When “None” is chosen for dustiness/mistiness level, this automatically causes the overall probability score to be “Extremely Unlikely”, regardless of what the other probability factors are. High: 30 pts, Medium: 15 pts, Low: 7.5 pts, None: 0 pts, Unknown: 22.5 pts.

3. Number of employees with similar exposure – points are assigned according to the number of employees authorized for the activity. >15: 15 pts, 11-15: 10 pts, 6-10: 5 pts, 1-5: 0 pts, Unknown: 11.25 pts.

4. Frequency of operation – points are assigned according to the frequency of the operation. Daily: 15 pts, Weekly: 10 pts, Monthly: 5 pts, Less than monthly: 0 pts, Unknown: 11.25 pts

5. Operation duration – points are assigned according to the duration of the operation. >4 hours: 15 pts, 1-4 hours: 10 pts, 30-60 min: 5 pts, Less than 30 min: 0 pts, Unknown: 11.25 pts.

Overall Risk Level

Based on the severity score and probability score, the following table is used to determine the overall risk level of the activity:

Probability

Severity	Extremely Unlikely (0-25)	Less Likely (26-50)	Likely (51-75)	Probable (76-100)
Very High (76-100)	RL 3	RL 3	RL 4	RL 4
High (51-75)	RL 2	RL 2	RL 3	RL 4
Medium (26 -50)	RL 1	RL 1	RL 2	RL 3
Low (0-25)	RL 1	RL 1	RL 1	RL 2

RL 1: General Ventilation
RL 2: Fume hoods or local exhaust ventilation
RL 3: Containment
RL 4: Seek specialist advice

http://controlbanding.net/Home.html
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Paik S, Zalk D, Swuste P. 2008. Application of a Pilot Control Banding Tool for Risk Level Assessment and Control of Nanoparticle Exposures. Ann. Occup. Hyg 52(6):419-428.