NANOTECHNOLOGY: AN INDUSTRIAL HYGIENE PERSPECTIVE

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Agenda

- Hazard Identification: (Recognition)
  - Defining Nanotechnology
  - Identification of new nanotechnology in process
  - Communication of hazard and risk information to users
- Risk Assessment (Evaluation)
  - Standard IH Assessment
  - Control Banding
- Risk Reduction (Control)
  - Work Environment Control
  - PPE
  - Medical Surveillance
  - Training
- Summary
HAZARD IDENTIFICATION

- Definition(s)
  - 1- to 100-nm size range
    - ISO
    - NIOSH/CSA Z12885
  - Limit scope to engineered and little or unknown toxicity data
    - Exclude materials with exposure limits
      - Carbon Black
      - Fumed Silica
Hazard Definition

- Nano-objects and Nano-materials
  - Matter at the nano-scale, at dimensions between 1 and 100 nanometers
  - Specifically engineered from nanoscale structures such as carbon nanotubes and filaments
  - Unique physical, chemical and biological properties
    - stain-free textiles
    - surface treatments
    - drugs
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>DESCRIPTION</th>
<th>HAZARD DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nanocomposite matrix- Solid Matrix</td>
<td>Nano-objects bound within a solid matrix and not easily, if at all, able to be released.</td>
<td>General safe handling; fire &amp; explosion potential if dust generated in process</td>
</tr>
<tr>
<td>2. Nanocomposite matrix-Liquid Dispersions</td>
<td>Nano-objects bound within a liquid matrix and not easily, if at all, able to be released.</td>
<td>General safe handling</td>
</tr>
<tr>
<td>3. Nano-structured Colloids-Liquid Suspensions</td>
<td>Unbound nano-objects (e.g. nanoparticles) added to a liquid such that they could be released if the liquid evaporates. Liquid vapor pressure and processing conditions need to be considered to determine evaporation potential.</td>
<td>Specific guidance for PPE and respirators, spill clean-up, waste disposal, labeling waste</td>
</tr>
<tr>
<td>4. Nano-objects, agglomerates &amp; nanoaerosols</td>
<td>Nano-objects are defined above. An agglomerate is a group of particles held together by relatively weak forces, including van der Waals forces, electrostatic forces or surface tension. Nanoaerosols are nano-objects suspended in a gas either in nanoscale or as aggregates or agglomerates due to the attractive forces, which will not readily reform nano-size unless much energy is expended, e.g. grinding or sanding. Micronized powders fall into this category.</td>
<td>Specific guidance for PPE and respirators, spill clean-up, waste disposal, labeling waste, check of controls, air emission controls, fire &amp; explosion potential</td>
</tr>
</tbody>
</table>
Hazard Definition – New Chemicals

- Hazard Communication
  - Review new MSDS for Nanomaterials
  - ID/Flag for Risk Assessment
  - Workplace labeling/training
- Management of Change Process
  - ID hazard/risk assessment/risk management for nanomaterials
- New Product Introduction processes
  - Communication of hazard to customers
Hazard Communication

No Universal Communication Criteria of Nanomaterials

- Communicate Hazard via MSDS/labeling/ internal work instructions
  - e.g. All hazardous Nanomaterials have health rating of 3-4 and special statement

- Supplement hazard communication training with internal Nanomaterial SOP

- Ensure communication to employees and customers is consistent

The winners of the “nano-hazard symbol” competition of the Canadian ETC-group

http://www.nanowerk.com/spotlight/spotid=26725.php#ixzz2MgyYmGaK

Dimitris Deligiannis, Greece

Shirley Gibson, Scotland

Kypros Kyprianou, England
Risk Assessments – IH Methods

- Nanomaterials with Occupational Exposure Limits
- NIOSH recommends exposure limits of 0.3 mg/m³ for ultrafine (including engineered nanoscale) TiO₂.
  - Air monitoring using NIOSH methods
- Control based on IH Data
  - Engineering
  - PPE
  - Medical Surveillance
- Protection from Dermal Exposure
# Recommended OELS for Nanomaterials

<table>
<thead>
<tr>
<th>Nanomaterial</th>
<th>OEL</th>
<th>Ref.</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium dioxide</td>
<td>0.3 mg/m³ ultrafine</td>
<td>NIOSH</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>2.4 mg/m³ fine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photocopier toner</td>
<td>0.06 mg/m³</td>
<td>BAuA</td>
<td>2009</td>
</tr>
<tr>
<td>CNTs</td>
<td>0.01 f/cm³</td>
<td>IFA</td>
<td>2009</td>
</tr>
<tr>
<td>Fibrous (3:1 aspect ratio, length 75,000 nm)</td>
<td>0.01 f/cm³</td>
<td>BSI</td>
<td>2007</td>
</tr>
<tr>
<td>MWCNTs</td>
<td>0.05 mg/m³</td>
<td>Bayer only</td>
<td>2010</td>
</tr>
<tr>
<td>MWCNTs</td>
<td>0.0025 mg/m³</td>
<td>Nanocyl only</td>
<td>2009</td>
</tr>
<tr>
<td>CNTs and nanofibers</td>
<td>0.007 mg/m³</td>
<td>NIOSH Draft REL</td>
<td>2010</td>
</tr>
</tbody>
</table>

Risk Assessments – Control Banding

Nanotechnology: The Next Big Thing of Much Ado about Nothing. Andrew Maynard

Conceptual interpretation of how a control-banding type of approach might be applied to airborne engineered nanomaterials.
CONTROL BANDING – IMPACT OR HAZARD ASSESSMENT CRITERIA

IMPACT OR HAZARD CRITERIA

- Chemical Composition (Lead/Carbon/Manganese)
- Material Characteristic (Dry Powder/Liquid Slurry/Solid)
  - Powder
  - Suspension in Liquid
  - Bound in Solid Matrix
- Particle Size Distribution (e.g. 30 to 70 nm)
- Toxicity of Parent Compound (may be unknown)
- OEL of Parent Compound (regulatory or TLV)
- Dustiness (Carbon Black vs Ceramics)
CONTROL BANDING – EXPOSURE ASSESSMENT CRITERIA

- Quantity Used per shift
- Route of Exposure during handling
- Frequency of Task
- Duration of Task
- Airborne Measurements
- Process/Engineering Controls in Place
Nano Risk Assessments

Control bands: assign numerical scores to Hazard and Exposure Criteria and place in Bands

1. Band 1 - good work practices, general ventilation,
2. Band 2 - add restricting work area, enclose system as much as possible, LEV, PPE
3. Band 3 - add enclose process as control methodology where feasible
4. Band 4 - Consult with industrial hygiene expert

In all bands, appropriate hazard communication training about the nanomaterials being handled is performed.
CONTROL BAND SUMMARY

- Mild/reversible
- Occupational Health Hazard
- Severe/irreversible

- Engineered Local Exhaust Ventilation
- Exposure Risk
- Closed Systems

- Quantity
- Task Duration

- 8 hours
- 15 minutes

- Milligrams
- Kilograms

- Slurry/suspension
- Agglomerated
- Highly disperse

Physical Form
Medical Surveillance

- Medical surveillance program should contain the following elements:
  - An initial medical evaluation
  - Periodic evaluations including symptoms surveys, physical exams, or specific medical tests based on data gathered in the initial evaluation.
  - Post-incident evaluations.
  - Periodic analysis of the medical screening data to identify trends or patterns.

NIOSH Current Intelligence Bulletin: Interim Guidance on Medical Screening of Workers Potentially Exposed to Engineered Nanoparticles
Nanoregistry

- Records who is potentially exposed
- What plant/lab locations
- What materials meeting the criteria
- When the projects occurred & duration

Use with general or existing medical surveillance

- Age related physicals
- Respiratory protection medical approvals
- Chemical specific surveillance

Future

- When medical surveillance is required for nanotechnology
- Possible epidemiology
CONCLUSIONS

- Nanotechnology is being introduced into labs and workplaces
- The standard Recognition/Evaluation/Control paradigm requires some alteration to identify hazard and manage risk
  - There are many unknowns about the hazard
  - Standard IH monitoring may not be applicable
- In order to protect employees, a written process needs to be developed
  - Hazard Identification
  - Hazard Evaluation
    - IH Monitoring
    - Control Banding
  - Risk Management
    - Including Medical Surveillance or Registry
REFERENCES


- General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories
  DHHS (NIOSH) Publication 2012-147

- Approaches to Safe Nanotechnology: Managing the Health and Safety Concerns Associated with Engineered Nanomaterials
  DHHS (NIOSH) Publication 2009-125

- Interim Guidance for Medical Screening and Hazard Surveillance for Workers Potentially Exposed to Engineered Nanoparticles
  DHHS (NIOSH) Publication No. 2009-116
THANK YOU

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