Control Banding & Nanotechnology-101

(NIEHS, RTP – October 21, 2009)

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NIOSH/CDC

The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

Scope of Exposures in the U.S.*

- 880,000 hazardous chemicals currently in use
- Potential exposure to hazardous chemicals:
  - >40 million employees
  - >5 million workplaces

Consequences of Exposures**

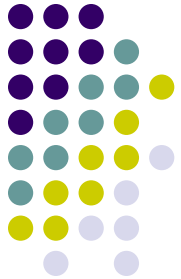
- 62,500 illnesses
- 17,340 illnesses and injuries involving days away from work

Sources:

*OSHA draft Proposed Rule for Hazard Communication modified to conform with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS), June 2009

**Bureau of Labor Statistics' data from 2006 and 2007 (most recent available)

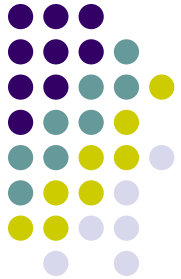
Global Challenges in Chemical Management



- Limited information for chemicals in commerce
- Limited resources (time, expertise, data) slow the chemical risk assessment/management process & OELs
- Lack of incentives/motivation for development of safer substitutes
- Need for integrated and universal approach to chemicals management
- Many strategies have been effective in controlling exposures for specific chemicals and their applications, but *no single strategy has been universally accepted or proven entirely effective*

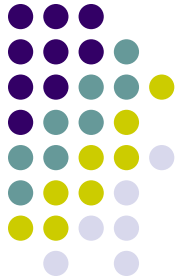
CONTROL BANDING

Focus on SMEs



- United States
  - 98% (6.3 million businesses) with fewer than 100 workers
  - More than half (56%) of workforce in these establishments
- U.K.
  - 99% (3.8 million businesses) have less than 200 workers; 69% are self-employed; 20% have 1-4 employees
- European Union
  - 99% of all businesses with fewer than 50 workers

Control Banding
(best practices and toolkits)



Risk Assessment / Management Paradigms

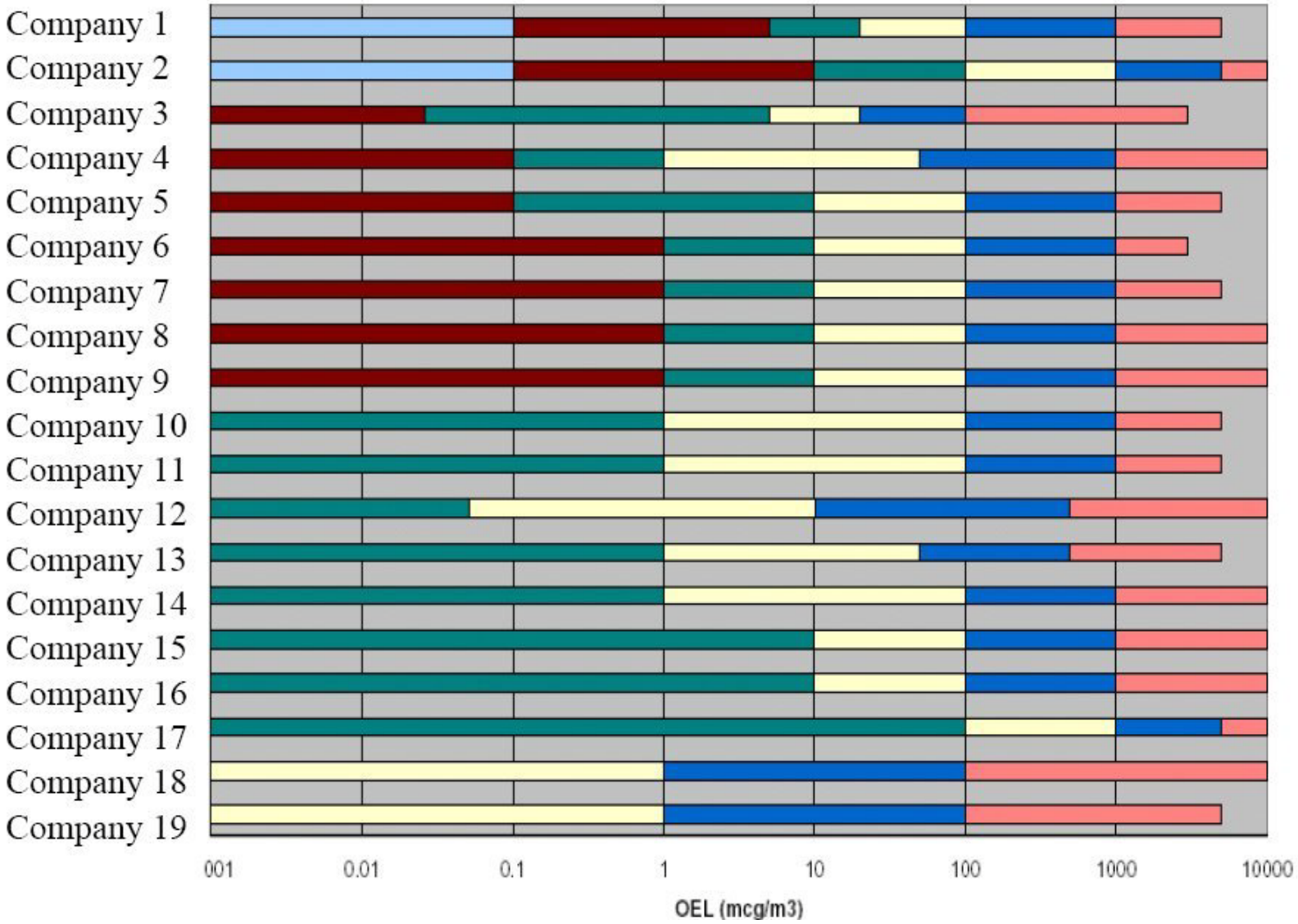
Traditional

1. Risk = (Hazard ➡ Exposure ➡ Control)

Pharmaceutical Industry (Control Banding)

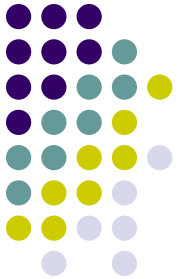
2. Risk = (Hazard ➡ Control ➡ Exposure)

Pharma Industry Bands



* Sources: Keith Tait, Corporate Health & Safety, Pfizer - National Control Banding Workshop, Washington, DC March, 2005 and David Eherts, Purdue Pharma - Control Banding from the Pharma Perspective: Staying Ahead of the Regulations, Oct. 2004

What is CONTROL BANDING?



1. a process in which a single ***control*** technology is applied to a range or ***band*** of exposures to a chemical that falls within a given hazard group.

2. an occupational risk assessment and management tool for use without on-site technical experts and expensive exposure measurements.

3. a simple matrix of toxicological endpoints (risk or hazard bands) and material use (exposure bands) used to determine which principles in the hierarchy of controls can be used to provide guidance for controlling exposures to hazards (control bands).

Small & Medium Enterprises BARRIERS

lack of expertise, technology, finances and time

and

need an adapted risk assessment approach.

- They want to be told what to do.
- They do not understand legal requirements.
- They do not receive or read safety materials.
- They consider distinctions between government environmental, health and safety regulations to be irrelevant.

Source: Paul Oldershaw, HSE, 1st International Control Banding Workshop, London, November 2002

Two Things Make Control Banding Possible

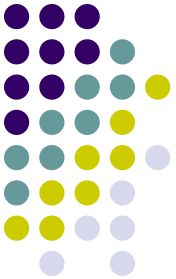
There are few basically different approaches to control. So we can band risks

Many problems have been met – and solved – before

Source: Paul Evans, 3rd International Control Banding Workshop, South Africa, September 2005

CONTROL BANDING

is NOT a NEW CONCEPT or APPROACH



Used worldwide for the transport of dangerous chemicals - classified with United Nations codes that are used for:

- identifying safe storage rules
- permitting types of transport containers
- taking actions during an emergency

Components of Control Banding

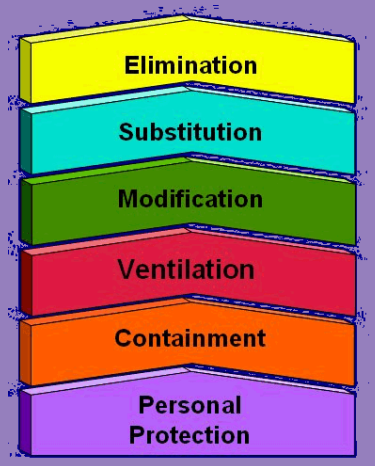
Hazard Assessment (toxicology) + **Workplace Exposure Assessment** (hygiene)

Risk Characterization

COSHH Essentials

1. Generic:
   - Task: How much?
   - How dusty?
   - How often?
   - R Phrase?
2. Direct Advice

Decide / Identify Control (hierarchy of controls)



Implement Control

- Access
- Design and equipment
- Maintenance
- Examination and testing
- Cleaning / Housekeeping
- PPE
- Training
- Supervision
- Employee checklist

Monitor / Verify

Review

UK Approach to Control Banding
COSHH Essentials

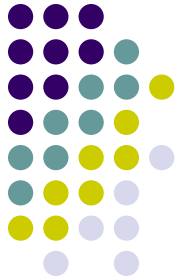
Control of Substances Hazardous to Health Essentials

Operator uses an on-line program to determine ..

- hazard rating from MSDS or IPCS card (R-phrases)
- quantity used (small, medium, large)
- physical form / characteristics (dust, vapor)
- data used to target control level (hierarchy of controls)
- specific control guidance sheet
- an action plan based on control guidance sheet

HSE
Health & Safety Executive

CONTROL BANDING
How to Use COSHH Essentials



- Step 1 – Getting started (substance name, supplier, tasks or process)
- Step 2 – Factors that decide your control approach
- Step 2A – What is the health hazard?
  - Obtain R-phrase or R-phrase combination from the MSDS
  - Determine the appropriate hazard group

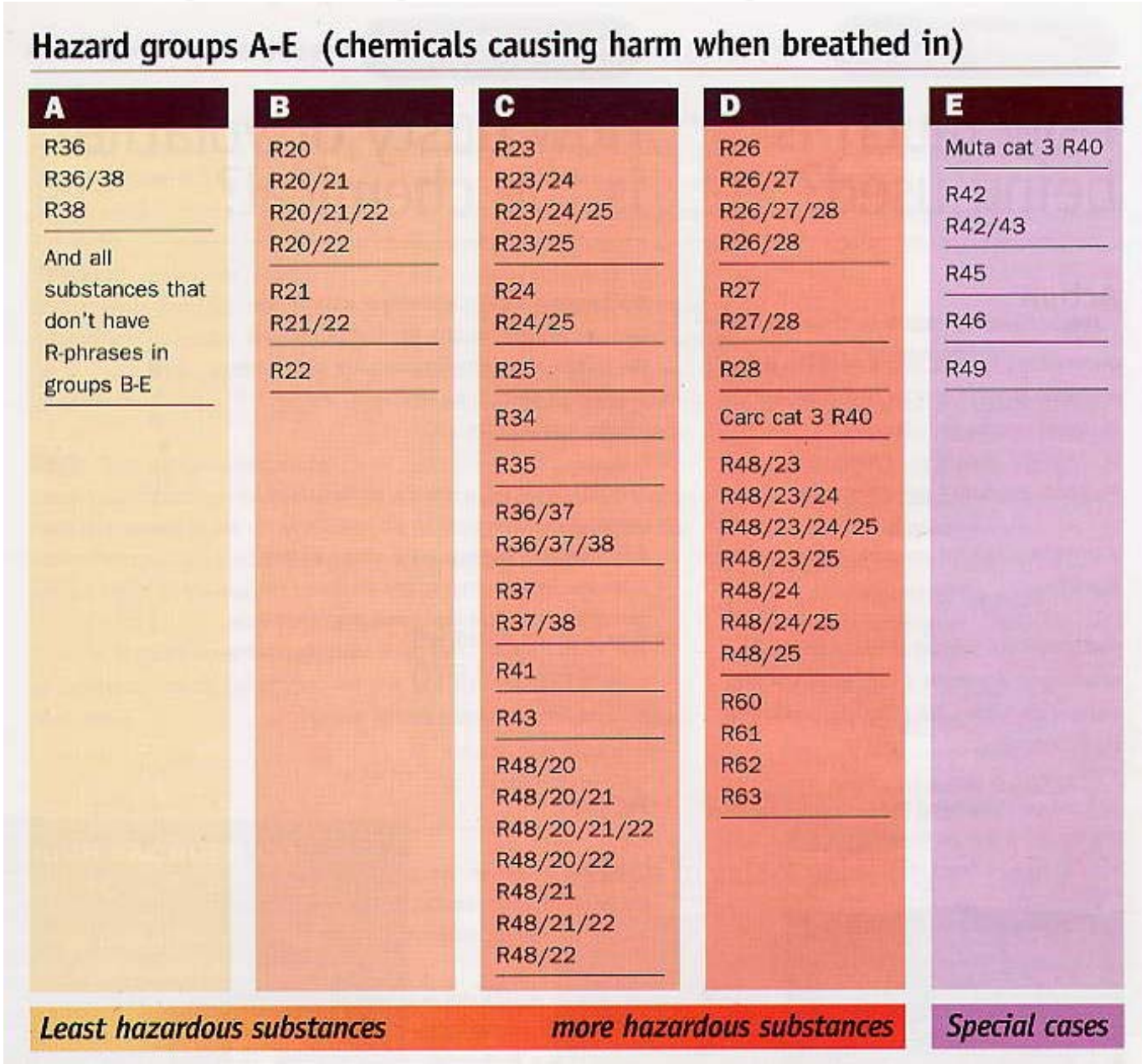
    low to high hazard A–D

    special cases E (carcinogens, mutagens, repro hazards)

    skin and eye hazard S

CONTROL BANDING

Key concept: Risk phrases – Step 2A

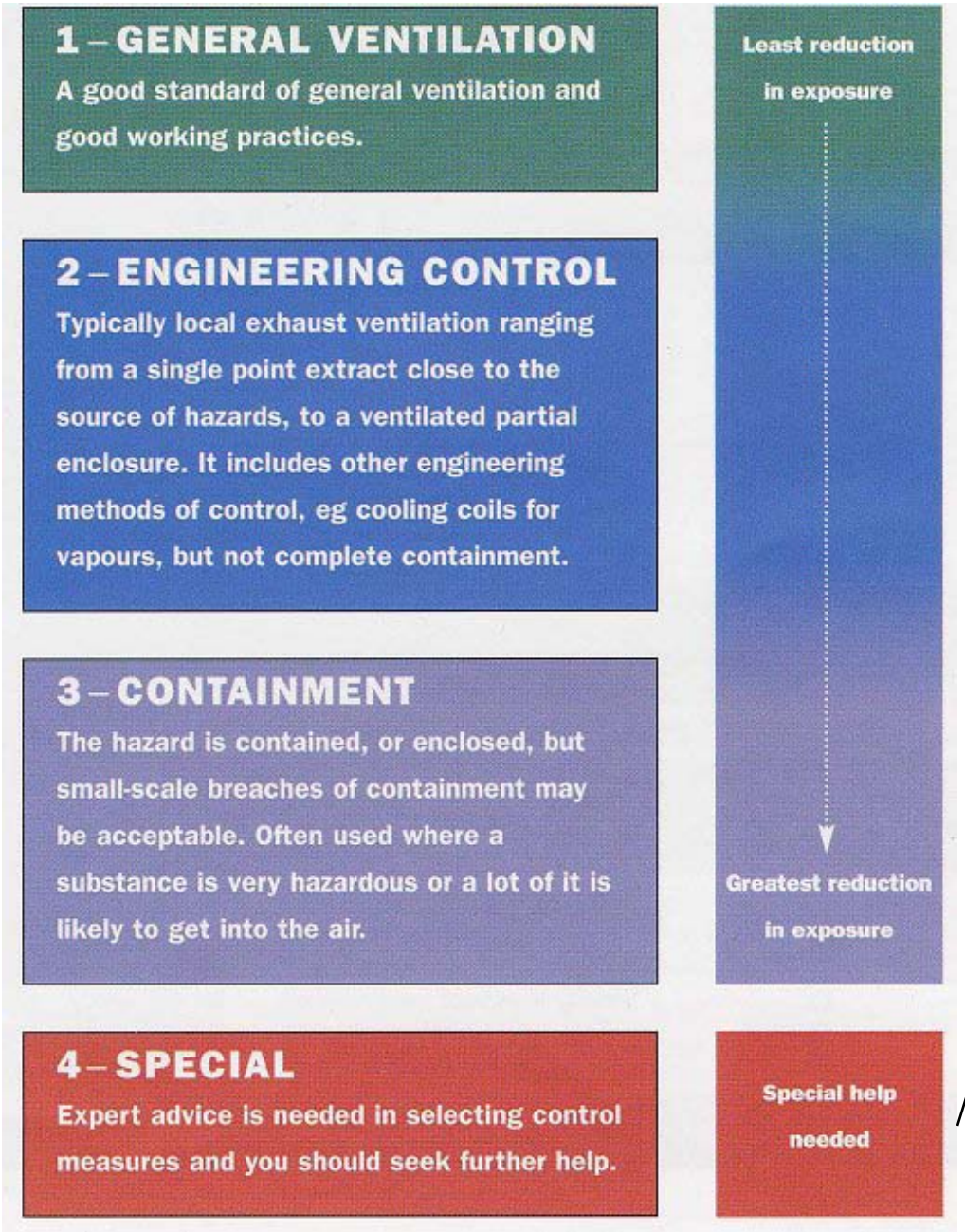


Step 2B – How much is used?		
AMOUNT	**SOLID**	**LIQUID**
Small	grams	milliliters
Medium	kilograms	liters
Large	tons	cubic meters

Step 2C – How dusty or volatile* is the chemical?	
LOW	pellet-like solids that don't break up, little dust is seen during use, e.g., PVC pellets, waxed flakes, prills
MEDIUM	crystalline, granular solids, Dust settles quickly, e.g., soap powder
HIGH	fine, light powders, dust clouds remain in air for several minutes e.g., cement, carbon black, chalk dust

**Similar matrix for categories of volatility based on the boiling point of substances and process operating temperatures.*

Step 3. Find the Control Approach



5. For some activities, processes, tasks, or jobs, specialists may identify that respiratory protective equipment (RPE), in combination with other control approaches, is always necessary.

Example COSHH Essentials Control Guidance Sheet

3

Control approach 3

Sack emptying

Containment 304

This guidance sheet is aimed at employers to help them comply with the requirements of the Control of Substances Hazardous to Health Regulations 1999 (COSHH) by controlling exposure to chemicals and protecting workers' health.

The sheet is part of the HSE guidance pack *COSHH essentials: easy steps to control chemicals*. It can be used where the guide recommends control approach 3 - containment - as the suitable approach for your chemical(s) and task(s).

This sheet provides good practice advice on sack emptying, and can be applied to tasks involving medium quantities of solids. It describes the key points you need to follow to reduce exposure to an adequate level.

It is important that all the points are followed.

Some chemicals can also be flammable or corrosive. Where they are, your controls must be suitable for those hazards too. Look at the safety data sheet for more information.

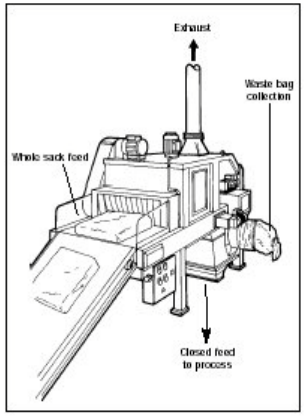
For certain processes your local authority or the Environment Agencies will impose emission limits under the Environmental Protection Act 1990. Air cleaning equipment may therefore be necessary before discharging some emissions into the atmosphere.

Access

- ✓ Control staff entry to the work area.
- ✓ The work area and equipment should be clearly labelled.

Design and equipment

- ✓ Provide arrangements to strip and vacuum or wet clean the conveyor belt.
- ✓ Enclose the slitter as much as possible - see diagram.
- ✓ Ensure an inward airflow of 1.0 metre per second at any opening into the enclosure.
- ✓ Keep all openings as small as possible - while allowing enough room for safe working. Use see-through panels and plastic strips to reduce the open area.
- ✓ Consider additional ventilation at the bag disposal point.
- ✓ Provide good lighting. Select lighting equipment suitable for the nature of the substances and processes, eg dust tight or flameproof, if needed.
- ✓ Design the system to allow easy maintenance.
- ✓ Where operational factors permit, keep the process equipment under negative pressure to prevent leakage.
- ✓ Discharge extracted air to a safe place away from doors, windows and air inlets.



Maintenance

- ✓ Ensure all equipment used in the task is maintained as advised by the supplier/installer, in effective and efficient working order and good repair.
- ✓ Adopt a 'permit to work' system for maintenance work.
- ✓ Follow any special procedures that are needed before the system is opened or entered, eg purging and washing.

Examination and testing (if a ventilation system is provided)

- ✓ Get information from the supplier on all parameters needed to safely operate the system.
- ✓ Visually check equipment at least once a week for signs of damage.
- ✓ Ensure any extraction equipment is thoroughly examined and tested against its performance standard. This is generally at least every 14 months (see HSE publication HSG54).
- ✓ Keep records of all examinations and tests for at least five years.

Cleaning and housekeeping

- ✓ Thoroughly clean work equipment and the work area daily. Clean other equipment and the workroom regularly - once a week is recommended.
- ✓ Store packages/containers in a safe place (see CGS 101).
- ✓ Dispose of empty packages/containers safely.
- ✓ Put lids on containers immediately after use.
- ✓ Deal with spills immediately.
- ✗ Don't clean up with a dry brush or compressed air, use a vacuum system or wet cleaning.

Personal protective equipment (PPE)

- ✓ Chemicals in hazard group S can damage the skin and eyes, or enter the body through the skin and cause harm. See CGS S100 and S101 for more specific advice. Check the safety data sheets to see what PPE equipment is necessary.
- ✓ Ask your safety clothing supplier to help you select suitable protective equipment.
- ✓ Respiratory protective equipment (RPE) shouldn't be needed for routine tasks. It may be necessary for some cleaning and maintenance activities, eg cleaning up spills. Be aware that some maintenance activity may involve entry into confined spaces. Decide if supplied air is needed when RPE is used.
- ✓ Ensure PPE is kept in a clean condition and replaced when necessary.

Training

- ✓ Give your workers information on the harmful nature of the chemicals.
- ✓ Provide them with training on: operating the process; following maintenance procedures; when and how to use PPE; and how to detect and deal with leaks.

Supervision

- ✓ Have a system to check that control measures are in place and being followed.

Further information

- Safety data sheets.
- *Maintenance, examination and testing of local exhaust ventilation* HSG54 HSE Books 1998 ISBN 0 7176 1485 9.
- *An introduction to local exhaust ventilation* HSG37 HSE Books 1993 ISBN 0 7176 1001 2.
- Control guidance sheets 101, 204, 302, S100 and S101.

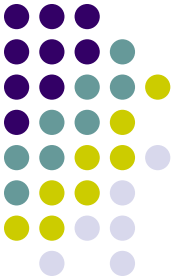
Employee checklist for making the best use of the controls

- ☐ Make sure any ventilation system is switched on and is working.
- ☐ Look for signs of leaks, wear or damage of any equipment used. If you find any problems, tell your supervisor. Do not carry on working if you think there is a problem.
- ☐ Avoid manual handling - use handling aids.
- ☐ Any damaged or leaking bags should be repacked away from the main storage area or disposed of safely. A responsible person should be involved to ensure this process is carried out safely.
- ☐ Wash your hands before and after eating, drinking or using the lavatory.
- ☐ Do not use solvents to clean your skin.
- ☐ Clear up spills straight away. For solids, use vacuum cleaning or wet mopping. Dispose of spills safely.
- ☐ Use, maintain and store any PPE provided in accordance with instructions.

COSHH essentials: easy steps to control chemicals HSG193 May 1999

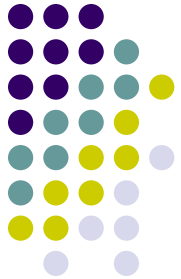
Printed and published by the Health and Safety Executive

Not a Bright Line!



Hazard Group vs. Target Exposure Range		
Hazard group	**Target airborne concentration range**	**R-phrases**
A -Skin and eye irritants	>1-10 mg/m3 dust >50-500 ppm vapor	R36, R38 All substances that do not have R phrases in groups B - E
B - Harmful on single exposure	>01-1 mg/m3 dust >5-50 ppm vapor	R20/21/22, R40/20/21/22
C -Severely irritating & corrosive, skin sensitizers	>0.01-0.1 mg/m3 dust >0.5-5 ppm vapor	R48/20/21/22, R23/24/25, R34, R35, R36/37, R37/38, R36/37/38, R37, R39/23/24/25, R41, R43
D -Very toxic on single exposure, reproductive hazard	< 0.01 mg/m3 dust < 0 5 ppm vapor	R48/23/24/25, R28/27/28. R39/26/27/28, Carc Cat 3 R40, R60. R61, R62, R63
E - Carcinogen, occupational asthma	*Seek Specialist Advice*	Muta Cat 3 R40, R42, R42/43, R45, R46, R49
S: Skin and eye contact	*Prevention or reduction of skin and/or eye exposure*	R21, R24, R27, R34, R35, R36, R38, R41, R43, R48/21, R48/24, plus R -phrase combinations containing these. Sk

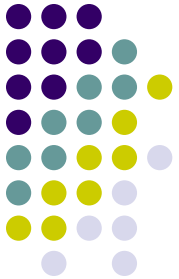
Control Guidance Grouping Assigned for Level of Risk				
Amount Used	Low Dustiness or Volatility	Medium Volatility	Medium Dustiness	High Dustiness or Volatility
Hazard Group A				
SMALL	1	1	1	1
MEDIUM	1	1	1	2
LARGE	1	1	2	2
Hazard Group B				
SMALL	1	1	1	1
MEDIUM	1	2	2	2
LARGE	1	2	3	3
Hazard Group C				
SMALL	1	2	1	2
MEDIUM	2	3	3	3
LARGE	2	4	4	4
Hazard Group D				
SMALL	2	3	2	3
MEDIUM	3	4	4	4
LARGE	3	4	4	4
Hazard Group E				
For all hazard group E substances, choose control approach 4				



Validation Results for Control Banding

Level of Control	*Percent of Substances Studied*
scheme equivalent to OEL	52
scheme more stringent than OEL	46
scheme less stringent than OEL	2
scheme equivalent or more stringent than OEL	98

Why Use Control Banding?



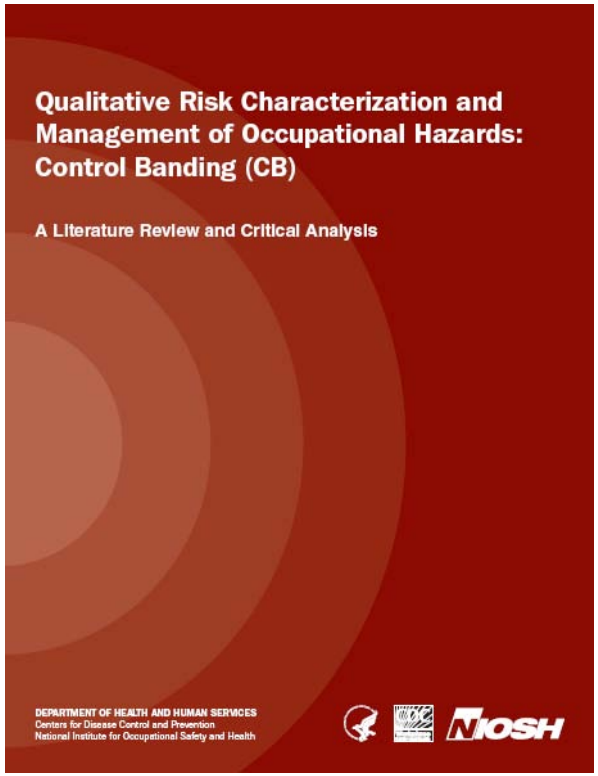
- ✓ A hazard classification and control focused approach (tool-kit)
- ✓ A *complementary approach* to traditional industrial hygiene which supplements OELs
- ✓ Focuses resources on exposure controls rather than exposure assessments
- ✓ Task based guidance in absence of OELs (new and existing)
- ✓ Provides technical expertise to chemical users through a simple interface
- ✓ Special Cases: encourages use of experts
- ✓ Particularly useful to SMEs
- ✓ Supports Globally Harmonized System for Hazard Communication (R- and S-phrases)

NIOSH Publication

Qualitative Risk Characterization and Management of Occupational Hazards: Control Banding (CB)

Scope: a literature review and critical analysis of the state-of-the-art, validation, and effectiveness of control banding (*August 2009*)

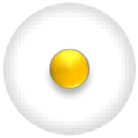
http://www.cdc.gov/niosh/docs/2009-152/

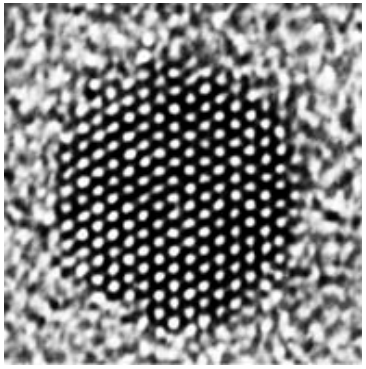


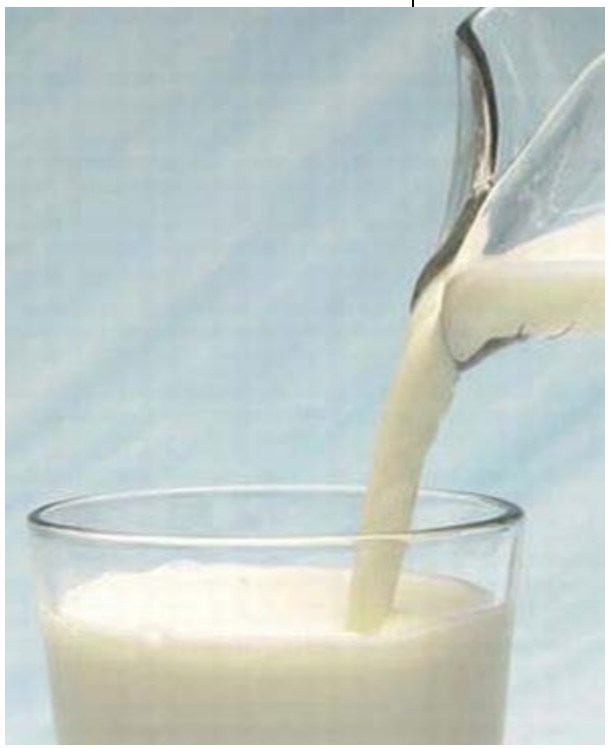
Nanomaterials

- 1 -100 nanometer size
  - naturally occurring (incidental)
  - specifically engineered
- Special properties
  - chemical, physical, electrical, mechanical, thermal
  - biological or environmental? Hazard (toxicology) is incomplete. (Gas exchange area of deposition, translocation, uptake via olfactory pathway directly to the brain, irritation, dermal penetration, lung fibrosis, platelet aggregation, etc.)
- Dosimetrics - **which one do I measure?**
  - size, shape, mass, number, surface area, composition
  - solubility, charge, functional groups, structure, impurities
- Risk Management
  - Are they hazardous? Can they be measured or controlled?
  - OEL for a material in its 'large' form may not be appropriate for the nano form

Size





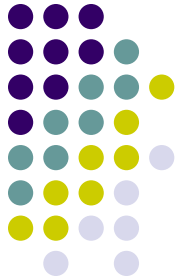


Atom
~0.1 nm

Nanoparticle
~ 1 – 100 nm

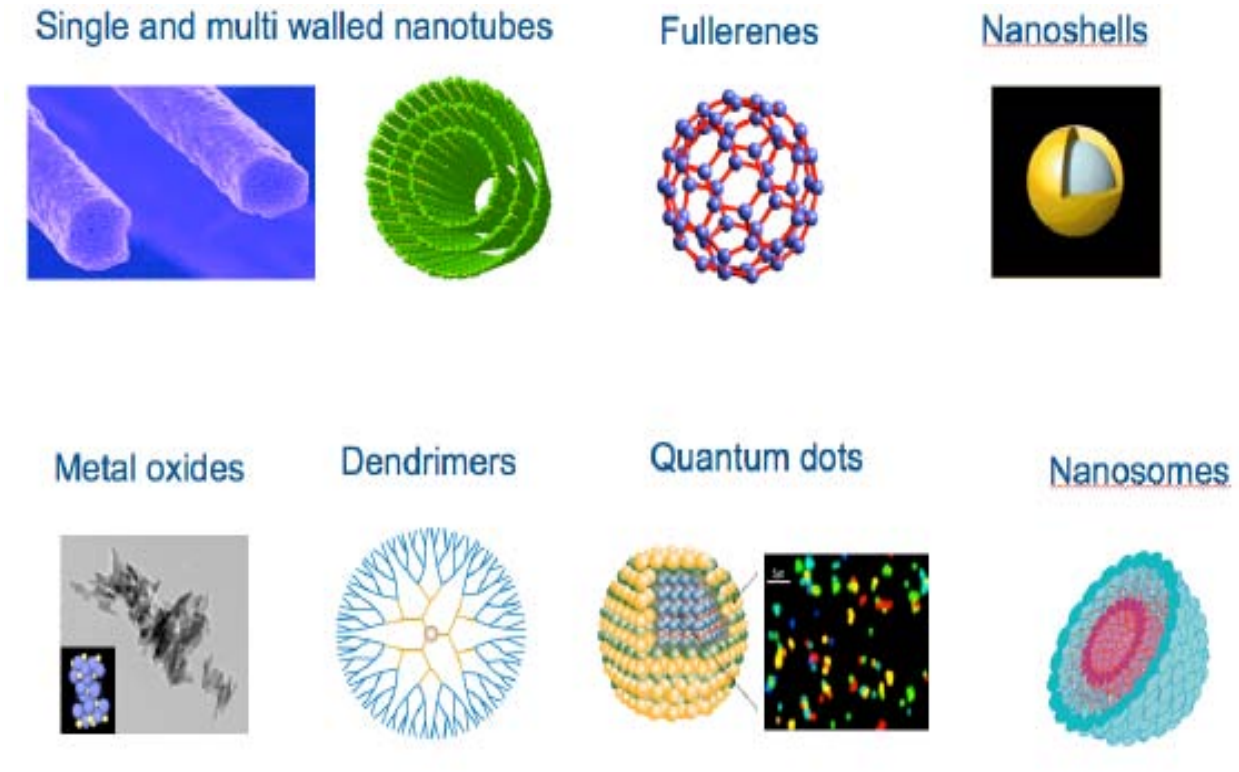
Colloidal particle
>100 nm

Types of Engineered Nanomaterials



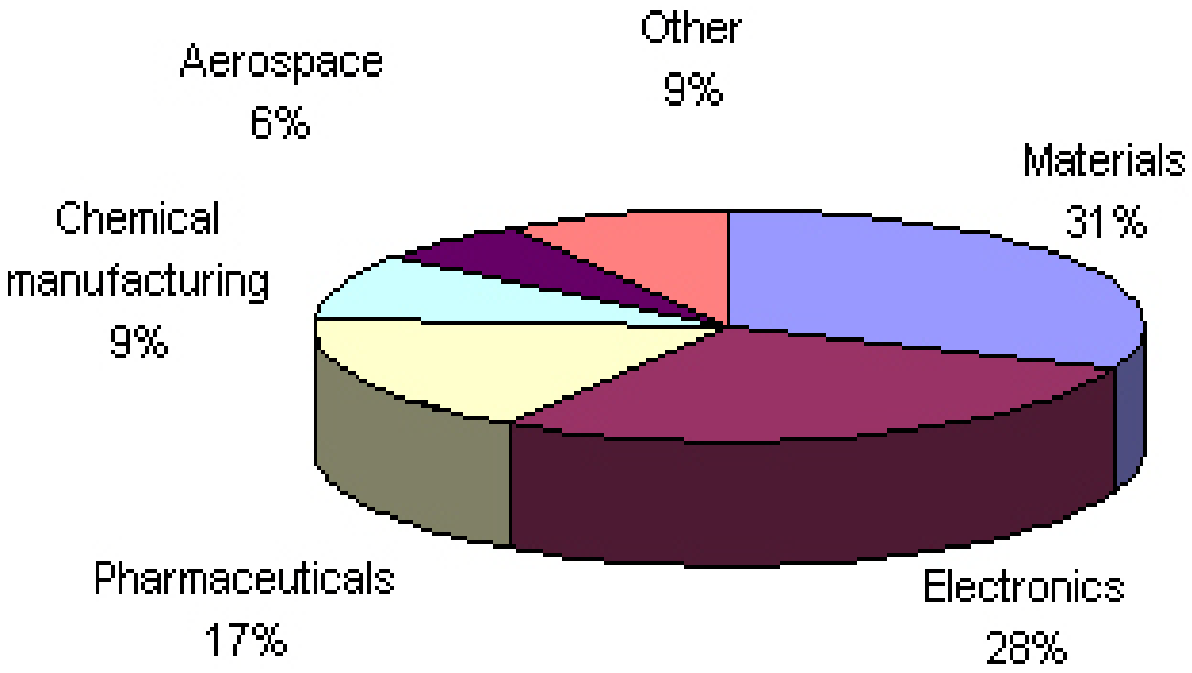
- Carbons - Fullerenes, nanotubes
- Oxides - TiO_2, ZnO, SiO_2, CeO_2, Fe_3O_4
- Metals - Ag, Fe, Al, Si, Zn, Cu, Ni
- Semiconductors - CdSe, CdS, InAs, InP
- Polymers/organics - liposomes, dendrimers
- Hybrids - nanoshells

Nanoparticles: Many shapes, many chemistries

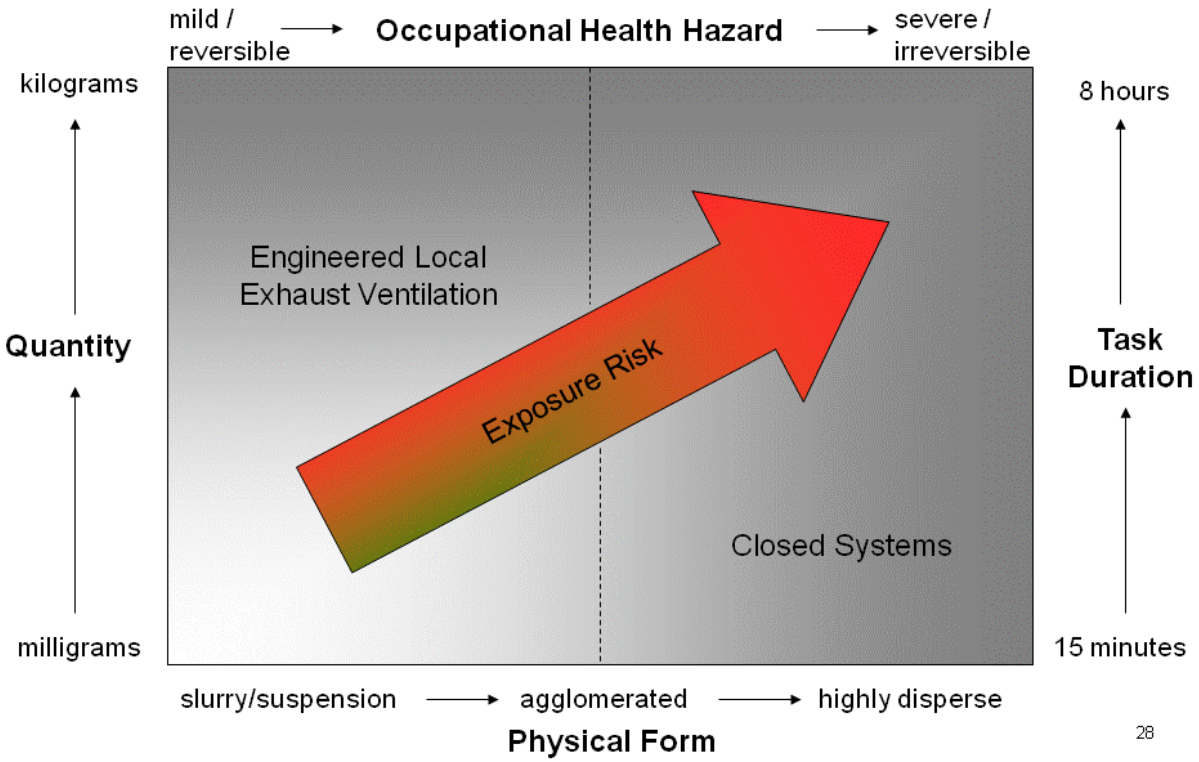


Not all nanoparticles are the same

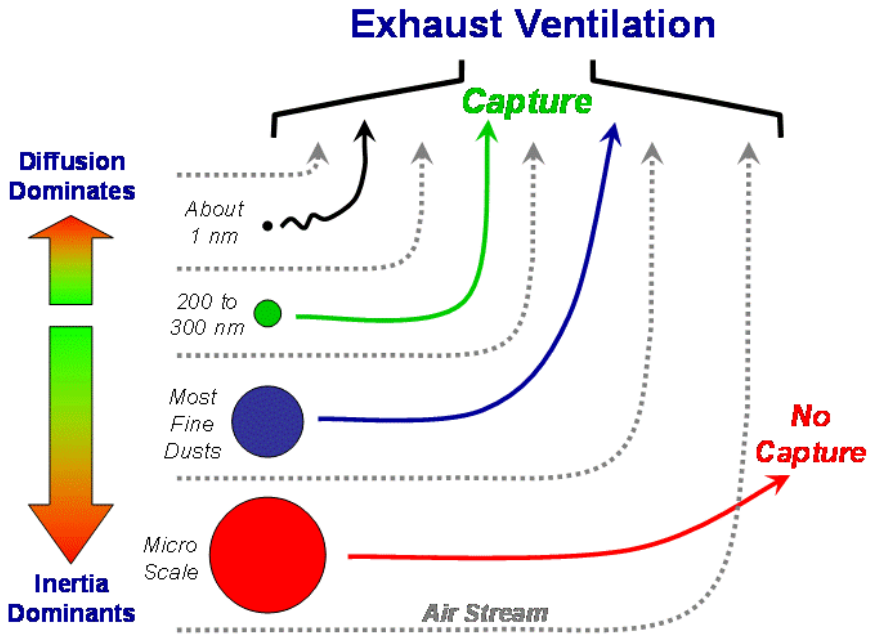
Nanotechnologies: Where?



Can they be controlled? Factors Influencing Control Selection



Conventional Controls Should Work



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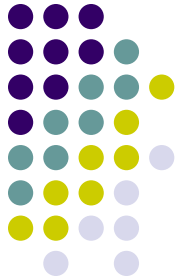
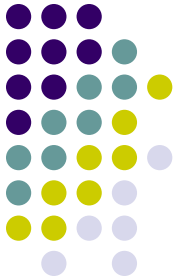
What about PPE ?

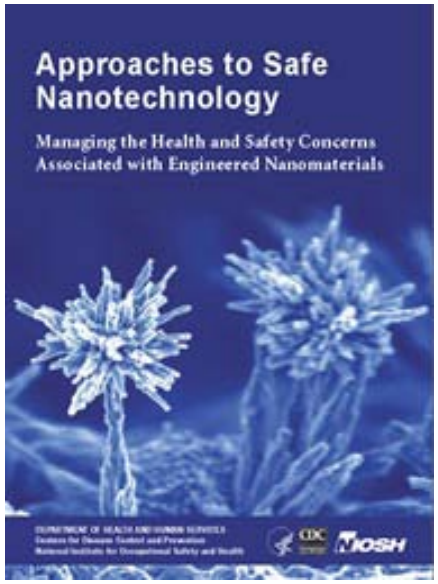


- Always the last line in the hierarchy of controls
- Prevent dermal exposure
- Use of respirators should be based on professional judgment and the results of hazard assessment and risk management practices

Proposed OELs for Engineered Nanoparticles

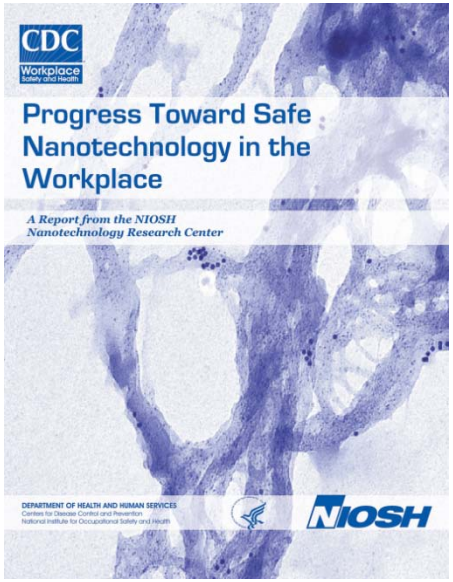


Nanomaterial	Parameter	OEL	Reference
General	0.004% Risk Level (4/100,000)	mass-based OEL 15	OECD, 2009
TiO_2	0.1% risk level particles <100nm Vs. normal size	0.1 mg/m^3 1.5 mg/m^3	NIOSH, 2009 (draft)
General Dust		3 mg/m^3	BAuA, 2009
Photocopier Toner	Tolerable Risk 2009 acceptable risk 2018 acceptable risk	0.6 mg/m^3 0.06 mg/m^3 0.006 mg/m^3	BAuA, 2008
Biopersistent Granular Materials (metal oxides, others	density >6,000 kg/m^3 density <6,000 kg/m^3	20,000 particles/cm^3 40,000 particles/cm^3	BGIA, 2009
CNTs	exposure risk ratio for asbestos	10,000 fibers/m^3	
Nano-scale Liquid	based on MAK or AGW		
Fibrous	3:1; length 75,000nm	0.1 fibers/m^3	BSI, 2007
CMAR (Carc., Mut., Asthma., Repro)	non-fibrous	mass-based OEL 15	
Soluble	non-fibrous ; non-CMAR		
Insoluble	non-fibrous	mass-based OEL 10	



Recommendations from NIOSH – Approaches to Safe Nanotechnology

- Summary of issues
- Approaches to consider
- Basic Guidance
- Updated as new information added on-line
- Input requested

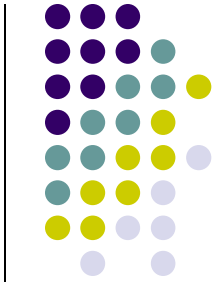


Progress Toward Safe Nanotechnology in the Workplace

- Research progress in 10 key areas
- Continuing project plans
- Opportunities for collaboration

www.cdc.gov/niosh/topics/nanotech

Resources and Web links



Control Banding and Tool Kits

- NIOSH Topic Page
  http://www.cdc.gov/niosh/topics/ctrlbanding/
- ILO SafeWork
  http://www.ilo.org/public/english/protection/safework/ctrl_banding/index.htm
- UK HSE COSHH Essentials
  http://www.coshh-essentials.org.uk/

Nanotechnology

- NIOSH Topic Page
  http://www.cdc.gov/niosh/topics/nanotech/
- NIOSH/Oregon State - Nanoparticle Information Library
  http://nanoparticlelibrary.net/index.asp
- *Good*Nano*Guide*
  http://www.goodnanoguide.org/

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Thank you for your attention!

Special Thanks to

Laura Hodson & Paul Schulte, NIOSH Nanotechnology Research Center