NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

NTRC | NANOTECHNOLOGY RESEARCH CENTER

Control Banding

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CDC Workplace Safety and Health | NIOSH

Overview

- History of Control Banding
- Control Banding Models
  - Overview of the Pharmaceutical Model

    Emerging chemicals and technologies
  - Overview of the Small Business Model

    Case Studies
  - Overview of Risk Prioritization Model

    Case Studies

Brief review of Important Terms

- Hazard – any source of potential damage, harm, or adverse health effect on someone (Ex: silica dust)

- Risk - the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard (Ex: the likelihood of developing cancer after exposure to silica dust)

Important Terms (continued)

- Adverse health effect- any change in body function or the structure of cells that can lead to disease or health problems

- Exposure- contact between an agent (silica dust, benzene) and a means of entry to the body (inhalation, ingestion, dermal absorption)

Important Terms

- Health Hazard Band – grouping of chemicals (or other agents) in categories of similar toxicity or risk characteristics

- Control Band – a group of controls that can be applied on several factors.

History of Control Banding

- In the 1970s a risk matrix was used by chemical facilities to predict the potential and severity of an event (i.e. explosion or chemical release)
- In the 1980s the pharmaceutical industry attempted to stratify hazards and link them to control strategies to protect workers
- In the 1990s levels of control were related to carcinogenicity

Source: Zalk D, Nelson D. 2008. History and Evolution of Control Banding: A Review. JOEH. 5(5):330-346.

History of Control Banding

- In 1996 the pharmaceutical industry expanded the use of the matrix to include biosafety levels based on toxicological data
- In 1997 the Chemical Industries Association (CIA) used risk categorization as a control guide
  - Linked five elements of CB:

    hazard categorization, hazard classification (i.e. toxic, corrosive), risk phrase, guideline control levels (i.e. OELs), and recommendations for each hazard category
  - Create occupational exposure bands (OEBs) to be used when there was no established OEL
- In 1998 the UK-Health & Safety Executive (HSE) developed the COSHH Essentials
  - Generic on-line risk assessment that incorporated ways to predict exposure

Control Banding Models

PHARMACEUTICAL INDUSTRY MODEL	SMALL BUSINESS MODEL	RISK EVALUATION AND PRIORITIZATION MODEL
Emerging issues New Chemical – OEL?	COSHH Essentials	Stoffenmanager 4.5 Stoffenmanager Nano CB Nanotool

Pharmaceutical Model

- Designed for substances with little to no toxicological data
  - New chemicals are treated as “highly potent” and controls are meant to reduce exposure to between 1 and 10 μg/m^3
  - Containment is verified with surrogate
  - Additional containment and PPE for substances known to be toxic
- Preliminary hazard assessment is required before scale-up occurs, including some toxicological data and potency information
  - Results are used to develop a “health hazard band” that includes dustiness, process, quantity, frequency, and duration

Hazard and Control Banding Summary for the Pharmaceutical Model

Category	Potency	Design	OEL Range
1	Low >100mg/day	Conventional open equipment; incidental contact with compound	>100 µg/m³
2	Moderate 10-100 mg/day	Gasketed, flanged equipment; laminar flow/directional laminar flow; enclosed transfers	100-10 µg/m³
3A	High 0.01-10 mg/day	Transfers using valves or other equal; containment for every disconnect	10-5.0 µg/m³
3B		High Containment, closed process trains, isolators	5.0-0.5 µg/m³
4	Extreme <0.01 mg/day	As above with additional redundancy and tighter containment specifications	<0.5 µg/m³

Summary of Pharmaceutical Model

- Useful for emerging technologies and chemicals without toxicological data or OELs
- Requires sampling using a surrogate to verify effectiveness of controls
- Substantial up-front cost to protect the researcher during the discovery phase

Evolution to Small Business Model

- The challenge to the Health Safety Executive (UK) was to develop a guide that:
  - Was designed for small to medium-sized businesses
  - Used available information (known toxicological data)
  - Was easy to use, understand, and reliable
  - Relayed the available information easily

Change of Focus

Traditional Method

Hazard

↓

Exposure

↓

Control

Control Banding Method

Hazard

↓

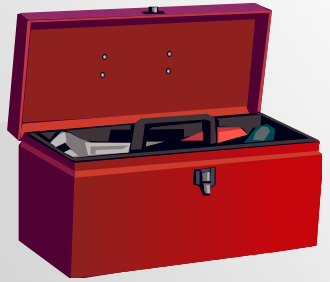
Control

↓

Exposure

*Keith Tait, Corporate Health & Safety, Pfizer
National Control Banding Workshop, Washington, DC March, 2005

Control Banding



- Generic risk evaluation technique and control of those risks

- Consists of grouping the health hazards (risk bands), the exposure potential (exposure bands), and combining these elements to generate a set of controls (control bands)

Control Banding

Is:

- A system that makes use of previous knowledge
- Task-based advice
- Useful to Small & Medium businesses
- Focused on controls

Is Not:

- Replacement for a professional (i.e. Industrial Hygienist)
- Replacement for health surveillance or environmental samples
- The only and last step - additional follow-up needs to be performed

Small Business Model

Health hazard band	+	Exposure potential		=	Control band
	Low risk	Scale of use	Potential for dispersion		
A. Skin and eye irritants		Small (g, ml)	Low		1. Ventilation and other good practices
B. Damaging		Medium (kg, l)	Medium		2. Engineering controls
C. Severe irritant, toxic, corrosive		Large (ton, m^3)	High		3. Containment
D. Very toxic, damaging to reproduction					4. Seek expert advice
E. Risk of cancer or genetic damage	High risk				

A	B	C	D	E
Skin/Eye Irritant or Not Hazardous	**Harmful on single exposure**	**Severely irritating, corrosive, or toxic**	**Very toxic on single exposure**	**Risk of cancer or genetic damage**
Risk Phrases				
R36 R36/38 R38 And all substances that don't have R-phrases in groups B-E	R20 R20/21 R20/21/22 R20/22 R21 R21/22 R22 H302 H312 H332 H371	R23 R23/24 R23/24/25 R23/25 R24 R24/25 R25 R34 R35 R36/37 R36/37/38 R37 R37/38 R41 R43 R48/20 R48/20/21 R48/20/21/22 R48/20/22 R48/21 R48/21/22 R48/22	R26 R26/27 R26/27/28 R26/28 R27 R27/28 R28 Carc. Cat. 3 R40 R48/23 R48/23/24 R48/23/24/25 R48/23/25 R48/24 R48/24/25 R48/25 R60 R61 R62 R63	Muta. cat 3 R40 R42 R42/43 R45 R46 R49

Least Hazardous → **Most Hazardous**

What is a Risk-Phrase (R-phrase)?

- Risk Phrases (R-phrase) is a system of hazard codes and phrases for labeling chemicals that is required by the European Union (EU) and found on Safety Data Sheets (SDS)
  - "R" followed by a combination of numbers
- R-phrases are used to identify the nature of the risk for handling dangerous substances
- Safety phrases (S-phrase) provide safety advice concerning handling dangerous chemicals

How will GHS effect R-phrases?

- Occupational Safety and Health Administration (OSHA) adopted GHS on May 25, 2012.
  - Compliance with all modified provisions of the final rule are expected by June 1, 2015
  - Distributors may not ship containers without a GHS label as of December 1, 2015
- R/S phrases are being phased out in favor of Hazard Statements and Precautionary Statements under Global Harmonization System (GHS)
- As R-phrases are being phased out and H-statements are being phased in, there will be an overlap.

EPA DOT CPSC

So what is GHS?

- A worldwide initiative to promote standard criteria for classifying and labeling chemicals according to their health, physical and environmental hazards.
- Benefits:
  - Enhance the protection of human health and the environment
  - Promote sound management of chemicals worldwide
  - Facilitate trade

GHS Label Elements

- Hazard Statements
- Pictograms
- Precautionary Statements
- Product Identifiers
- Signal Words
- Supplier Identification

Small Business Model

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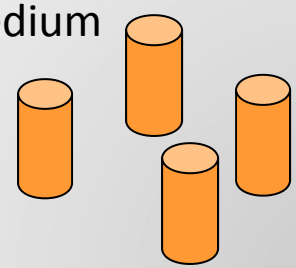
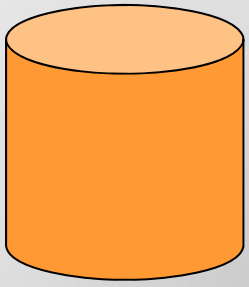
Least Hazardous → **Most Hazardous**

Exposure Potential-Quantity

Determine the quantity of chemicals required for the task			
Quantity	**Weight**	**Volume**	**Packaging**
Small 	Grams (g)	Milliliters (ml)	Packet or bottles 
Medium 	Kilograms(kg)	Liters (l)	Kegs or drums 
Large 	Tons (t)	Cubic Meters (m^3)	Bulk 

Exposure Potential: Dispersion

Dustiness of a solid	
Low	Solids that don't break up. Very little dust is seen during use. (Ex. Pellets)
Medium	Crystalline granular solids. Some dust is seen but settles quickly. Dust remains on surfaces. (Ex. Detergent)
High	Fine, light powders. Dust clouds can bee seen and remain in the air for several minutes. (Ex. Chalk dust, carbon black)

Volatility of a liquid	
Low	Boiling point above 150°C
Medium	Boiling point between 150°C and 50°C
High	Boiling point below 50°C
Volatility refers to the ability of a liquid to turn into a vapor. A process being carried out above room temperature will typically increase volatility. If you are using two or more substances with different boiling points, use the lowest boiling point	

Control Approaches

1-General Ventilation
A good standard of general ventilation and good work practices.

2-Engineering Control
Typically local exhaust ventilation, but also includes other types of engineering controls, but not containment.

3-Containment
Completely contain or enclose the hazard, such as inside a glovebox.

4-Special
Expert advice is needed in selecting appropriate control measures.

Determining the necessary Control Approach

Dispersion Potential / Quantity	**Low** Dustiness/Volatility	**Medium** Volatility	**Medium** Dustiness	**High** Dustiness/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
	For all substances in **Hazard Group E**, control approach 4 is required.			

Control Banding Case Study - 1

Are the employees adequately protected?

- Woodcraft Furniture store has 15 employees
- Employees apply Waterlox® Satin finish with a rag, 6 times a day for 30 min each time
- The 1.5 liter containers are stored in a flammable cabinet, 3 containers are used a day
- It is applied in a basement room at room temperature.
- There is a portable fan in the room, and the windows and door are open

Quick Review

- What information do you need to apply the control banding method to this case study?
  - Safety Data Sheet → Which contain the R-phrases, substance description, boiling point, etc…
  - Determine the Health hazard band based on the R-phrase
  - Determine quantity of the substance used in the task
  - Determine volatility or dustiness of the substance

HARMFUL OR FATAL IF SWALLOWED- CAN ENTER LUNGS AND CAUSE DAMAGE

MAY CAUSE RESPIRATORY TRACT IRRITATION IF INHALED

Material Safety Data Sheet

Waterlox

24-Hour Emergency Telephone Number

EMERGENCY RESPONSE SERVICE: CHEMTEL 1.800.255.3924 OR 1.800.CHEMTEL

SECTION 1 PRODUCT AND COMPANY IDENTIFICATION

Original Satin Finish

Product Number(s): TB 6022

Company Identification
Waterlox Coatings Corp.
9808 Meech Ave
Cleveland, OH 44105
USA

Product Information
MSDS Requests: 1-216-641-4877 (USA)
Product Information: 1-216-641-4877 (USA)
info@waterlox.com

Date of Preparation: 6-03-04

SECTION 2 COMPOSITION/ INFORMATION ON INGREDIENTS

COMPONENTS	CAS NUMBER	AMOUNT
Stoddard Solvent	8052-41-3	< 70.0% weight
1,2,4 - Trimethylbenzene	95-63-6	< 5.0% weight
1,3,5 - Trimethylbenzene	108-67-8	< 5.0% weight
Cobalt Naphthenate	61789-51-3	< 1.0% weight

SECTION 3 HAZARDS IDENTIFICATION

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EMERGENCY OVERVIEW

Dark amber liquid with hydrocarbon odor.

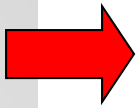
- COMBUSTIBLE LIQUID AND VAPOR
- HARMFUL OR FATAL IF SWALLOWED - CAN ENTER LUNGS AND CAUSE DAMAGE
- MAY CAUSE RESPIRATORY TRACT IRRITATION IF INHALED
- MAY CAUSE SKIN IRRITATION
- TOXIC TO AQUATIC ORGANISMS

****

IMMEDIATE HEALTH EFFECTS
Eye: Not expected to cause prolonged or significant eye irritation.
Skin: Contact with the skin causes irritation. Symptoms may include pain, itching, discoloration, swelling, and blistering. Contact with the skin is not expected to cause an allergic skin response. Not expected to be harmful to internal organs if absorbed through the skin.
Ingestion: Because of its low viscosity, this material can directly enter the lungs, if swallowed, or if subsequently vomited. Once in the lungs it is very difficult to remove and can cause severe injury or death. May be irritating to mouth, throat, and stomach. Symptoms may include nausea, vomiting, and diarrhea.

R-Phrases:

R22
R36/37/38
R48
R65
R67



Use material for its intended purpose or recycle if possible. This material, if it must be discarded, may meet the criteria of a hazardous waste as defined by US EPA under RCRA (40 CFR 261) or other State and local regulations. Measurement of certain physical properties and analysis for regulated components may be necessary to make a correct determination. If this material is classified as a hazardous waste, federal law requires disposal at a licensed hazardous waste disposal facility.

SECTION 14 TRANSPORT INFORMATION

The description shown may not apply to all shipping situations. Consult 49CFR, or appropriate Dangerous Goods Regulations, for additional description requirements (e.g., technical name) and mode-specific or quantity-specific shipping requirements.

DOT Shipping Name: Paint
DOT Hazard Class: 3 (Flammable Liquid)
DOT Identification Number: UN1263
DOT Packing Group: III

SECTION 15 REGULATORY INFORMATION

RISK PHRASES:
22 Harmful if swallowed.
36/37/38 Irritating to eyes, respiratory system, skin.
48 Danger of serious damage to health by prolonged exposure.
65 Harmful: may cause lung damage if swallowed.
67 Vapours may cause drowsiness and dizziness.

SAFETY PHRASES:
2 Keep out of reach of children.
23 Do not breathe vapour.
26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
36/38 Wear suitable protective clothing and respiratory equipment.
45 In case of accident or if you feel unwell, seek medical advise immediately (show the label whenever possible).
51 Use only in well ventilated areas.
62 If swallowed, do not induce vomiting; seek medical advice immediately and show this container or label.

NATIONAL REGULATIONS:

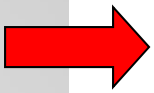
SARA 313
This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372:

CHEMICAL NAME	CAS NUMBER	Wt % is less than
1,2,4 Trimethylbenzene	95-63-6	5.0
1,3,5 Trimethylbenzene	108-67-8	5.0
Cobalt Naphthanate	6789-51-3	1.0

NEW JERSEY RIGHT – TO - KNOW
The following materials are non-hazardous, but are among the top five components in this product:

CHEMICAL NAME	CAS NUMBER

Boiling Point:
150-199°C



(Note: Avoid contact with water. PVA deteriorates in water.), Viton
Respiratory Protection: Determine if airborne concentrations are below the recommended exposure limits. If not, wear a NIOSH approved respirator that provides adequate protection from measured concentrations of this material, such as: Air-Purifying Respirator for Organic Vapors
Use a positive pressure, air-supplying respirator if there is potential for uncontrolled release, exposure levels are not known, or other circumstances where air-purifying respirators may not provide adequate protection.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Dark amber liquid with hydrocarbon odor.
Vapor Pressure: Heavier than air
Vapor Density (Air = 1): NDA
Boiling Point: 150 – 199C (300 - 390 F)
Solubility: Insoluble in water.
Density: 0.8431
Weight per Gallon: 7.04 lbs/gal

SECTION 10 STABILITY AND REACTIVITY

Chemical Stability: This material is considered stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.
Incompatibility With Other Materials: May react with strong oxidizing agents, such as chlorates, nitrates, peroxides, etc.
Hazardous Decomposition Products: None known (None expected)
Hazardous Polymerization: Hazardous polymerization will not occur.

SECTION 11 TOXICOLOGICAL INFORMATION

IMMEDIATE HEALTH EFFECTS
Eye Irritation: The eye irritation hazard is based on evaluation of data for similar materials or product components.
Skin Irritation: The skin irritation hazard is based on evaluation of data for similar materials or product components.
Skin Sensitization: The skin sensitization hazard is based on evaluation of data for similar materials or product components.
Acute Dermal Toxicity: The acute dermal toxicity hazard is based on evaluation of data for similar materials or product components.
Acute Oral Toxicity: The acute oral toxicity hazard is based on evaluation of data for similar materials or product components.
Acute Inhalation Toxicity: The acute inhalation toxicity hazard is based on evaluation of data for similar materials or product components.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY
NDA

ENVIRONMENTAL FATE
NDA

SECTION 13 DISPOSAL CONSIDERATIONS

Worksheet -- Control Banding

Task: _____

Health Hazard		Exposure Potential		Control Band
Chemical	R-Phrase	Quantity	Dispersion	
Risk Group		Scale of Use	Potential	
A B C D E		Small Medium Large	Low Medium High	

Worksheet -- Control Banding

Task: Applying tint with a rag

Health Hazard					Exposure Potential				Control Band
Chemical	R-Phrase				Quantity	Dispersion			
Original Satin Finish	R-22 R-36/37/38 R-48				1.5 liters 6 times/day	Temperature of application: 25C			Level 2: Engineering Controls (Local Ventilation)
Stoddard Solvent	R-65 R-67				30 minutes each application	Boiling Point 150-199 C			Substitution Gloves
Risk Group					Scale of Use		Potential		
A	B	C	D	E	Small		Low	X	
		X							
R-36/37/38					Medium	X	Medium		
					Large		High		

Determining the necessary Control Approach

Dispersion Potential / Quantity	**Low** Dustiness/Volatility	**Medium** Volatility	**Medium** Dustiness	**High** Dustiness/Volatility
	Hazard Group A			
Small	1	1	1	1
Medium	1	1	1	2
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	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
	For all substances in **Hazard Group E**, control approach 4 is required.			

Control Approaches

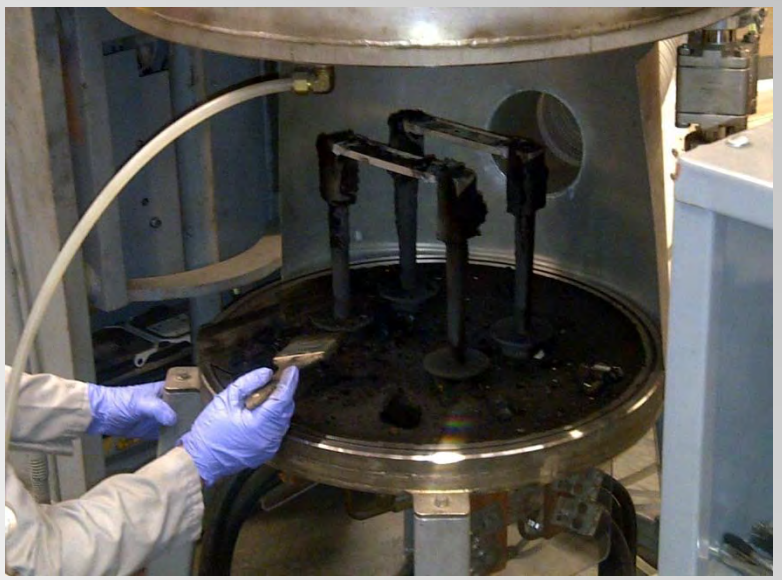
1-General Ventilation
A good standard of general ventilation and good work practices.

2-Engineering Control
Typically local exhaust ventilation, but also includes other types of engineering controls, but not containment.

3-Containment
Completely contain or enclose the hazard, such as inside a glovebox.

4-Special
Expert advice is needed in selecting appropriate control measures.

Control Banding Case Study - 2



Are the employees adequately protected?

- Nano Services has two employees
- Employees manually clean 1 kilogram of dried nano-metal oxide, silver (8-20 nm), powder out of a reactor each day.
- There are 6 reactors, each is cleaned once daily, five days a week.
- The time to complete cleaning is 30 minutes.
- The reactor remains at room temperature during the cleaning process.
- Currently, employees wear nitrile gloves, full-face respirators, and lab coats. Local exhaust ventilation is used.

Harmful if swallowed. May cause skin or eye irritation. May cause agyria.

May be harmful if inhaled. Material may be irritating to nasal septum, throat, mucous membranes, and upper respiratory tract.

Material Safety Data Sheet
Silver Powder

1. Product and Company Identification

PRODUCT NAME: Silver Powder
SYNONYMS: Ag, Argentum, Silver, Silver Particles, Ultra-fine Silver

MANUFACTURER:
ADDRESS:

EMERGENCY PHONE
(CHEMTREC):
OTHER CALLS:
FAX:

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Silver	7440-22-4	> 99.9%	No

CHEMICAL NAME: Silver
CHEMICAL FAMILY: Metal Powder
CHEMICAL FORMULA: Ag

3. Hazards Identification

Safety Data
HMIS Ratings: Health=0, Flammability=0, Reactivity=1
Lab Protective Equip: Goggles, gloves, lab coat
Potential Health Effects
Inhalation: May be harmful if inhaled. Material may be irritating to nasal septum, throat, mucous membranes and upper respiratory tract.
Ingestion: May be harmful if swallowed. May cause gastrointestinal irritation with nausea, vomiting and diarrhea.
Skin Contact: May cause skin irritation or ulceration.
Eye Contact: May cause eye irritation or blue-gray eyes.
Chronic Exposure: Absorption of silver compounds by ingestion, inhalation or through broken skin can cause argyria, a permanent bluish-gray discoloration of the skin, conjunctiva and mucous membranes.

PLEASE NOTE THAT NO R-PHRASES ARE LISTED

15. Regulatory Information

--Chemical Inventory Status – Part 1--

Ingredient	TSCA	EC	Japan	Australia
Silver (7440-22-4)	Yes	not available		

Chemical Inventory Status – Part 2-

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Silver (7440-22-4)	No	Yes	No	

Federal, State & International Regulations – Part 1-

Ingredient	--SARA 302-- RQ	TPQ	------SARA 313------ List	Chemical Catg.
Silver (7440-22-4)			Yes	

Federal, State & International Regulations – Part 2 -

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8 (d)
Silver (7440-22-4)	5000	No	No

Chemical Weapons Convention: No
TSCA 12(b): No
CDTA: No
SARA 311/312: Acute: Yes, Chronic: Yes, Fire: No, Pressure: No, Reactivity: No (Pure / Solid)
Australian Hazchem Code: None allocated.
Poison Schedule: None allocated.
WHMIS: This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

Label Precautions: Avoid contact with eyes, skin and clothing. Wash thoroughly after handling. Avoid breathing dust or vapors. Keep container closed. Use only with adequate ventilation.

Label First Aid: If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. In all cases, seek medical attention.

Product Use: Laboratory Reagent.

Disclaimer: QuantumSphere, Inc. believes that the information in this Material Safety Data Sheet is accurate and represents the best and most current information available to us. However, we make no warranty of merchantability or any other warranty, expressed or implied, with respect to such information, and we assume no liability resulting from its use or misuse. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no way shall QuantumSphere be liable for any claims, losses or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if the company has been advised of the possibility of such damages.

Last updated 05/24/07

Boiling Point: 2212°C

Airborne Exposure Limits:
- OSHA Permissible Exposure Limit (PEL) 0.01 mg/m3 (TWA)
- NIOSH Recommended Exposure Level (REL) 0.01 mg/m3 (TWA)
- NIOSH Immediately Dangerous to Life or Health Concentration (IDLH) 10 mg/m3
- ACGIH Threshold Limit Value (TLV) 0.1 mg/m3 (TWA)

Ventilation System: A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emission of the contaminant at its source, preventing dispersion of it into the general work area.

Respiratory Protection Equipment:
Respirators may be necessary when engineering and administrative controls do not adequately prevent exposures. Currently, there are no specific exposure limits for airborne exposures to engineered nanoparticles although occupational exposure limits exist for larger particles of similar chemical composition. The decision to use respiratory protection should be based on professional judgment that takes into account toxicity information, exposure measurement data, and frequency and likelihood of the worker's exposure. Preliminary evidence shows that for respiration filtration media there is no deviation from the classical single-fiber theory for particulates as small as 2.5 nm in diameter. While this evidence needs confirmation, NIOSH certified respirators will be useful for protecting workers from nanoparticles inhalation when properly selected and fit tested as part of a complete respiratory protection program. Use NIOSH approved positive flow mask if dust becomes airborne. Try to avoid creating dust conditions.

Skin Protection: Wear impervious protective clothing including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact. Wash thoroughly after handling. Maintain quick-drench facilities in work area.

Eye Protection: Use chemical safety goggles and/or full face shield where dusting or splashing of solution is possible. Maintain eye wash fountain in work area.

9. Physical and Chemical Properties

Appearance:	Dark gray to black powder with an average particle size of 20-100 nanometers.
Odor:	Odorless
Solubility:	Insoluble in water
Theoretical Density:	10.49 g/cm3
Bulk Density:	0.5 g/cm3
Molecular Weight:	107.868 AMU
pH:	Not available
Boiling Point:	2212C (4014F)
Melting Point:	962C (1764F)
Vapor Density (Air=1):	Not available
Vapor Pressure:	Not available
Evaporation Rate:	Not available
Viscosity:	Not applicable
Decomposition Temp:	Not available

10. Stability and Reactivity

Stability: Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products: Metal oxide fume.
Hazardous Polymerization: Will not occur.
Incompatibilities: Silver is incompatible with acetylene, ammonia, strong hydrogen peroxide solutions,

Worksheet -- Control Banding

Task: _____

Health Hazard		Exposure Potential		Control Band
Chemical	R-Phrase	Quantity	Dispersion	
Risk Group		Scale of Use	Potential	
A B C D E		Small Medium Large	Low Medium High	

Worksheet -- Control Banding

Task: Manual cleaning of nano-silver production reactor at Nano Services

Health Hazard		Exposure Potential		Control Band
Chemical	R-Phrase	Quantity	Dispersion	
Nano-silver	None available	-1 kilogram -6 reactors -cleaned once daily -30 min. each	-Applied at room temp. -Boiling point: 2212° C -Low volatility -Dry powder	Level 3: Containment Completely contain or enclose the hazard, such as inside a glovebox.
Risk Group		Scale of Use	Potential	
A B C X D E Estimation based on hazard identification in part 3 of MSDS		Small Medium X Large	Low Medium High X	

Determining the necessary Control Approach

Dispersion Potential / Quantity	**Low** Dustiness/Volatility	**Medium** Volatility	**Medium** Dustiness	**High** Dustiness/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
	For all substances in **Hazard Group E**, control approach 4 is required.			

Control Approaches

1-General Ventilation
A good standard of general ventilation and good work practices.

2-Engineering Control
Typically local exhaust ventilation, but also includes other types of engineering controls, but not containment.

3-Containment
Completely contain or enclose the hazard, such as inside a glovebox.

4-Special
Expert advice is needed in selecting appropriate control measures.

COSHH Essentials

- Control of Substances Hazardous to Health (COSHH)
- Provides an on-line control banding tool to recommend a control level
- Enter data step-by-step, and receive guidance sheets to assist in control of this chemical
- Limited to substances classified under European Chemical Hazardous Information & Packaging (CHIP) regulation
- Excludes pesticides, pharmaceuticals, and process-generated hazards (wood dust, silica dust, and welding fumes)

COSHH Essentials Case Study

www.coshh-essentials.org.uk

- Tasty Popcorn Company has 25 employees
- Employees add liquid artificial butter flavor to the popcorn at the beginning of each batch
- 4 Batches are produced per day and 2 liters are added to each batch
- It takes 30 minutes to transfer and add the artificial butter flavor to each batch
- The facility is kept at room temperature
- See MSDS for additional information

Summary of the Small business model

- Sharing the knowledge and experiences of experts with those that have fewer resources
  - There are approximately 3 billion workers in the world. 90% do not have access to occupational safety and health experts.
- Many hazards have been successfully controlled in the past

Limitations of the Small Business model

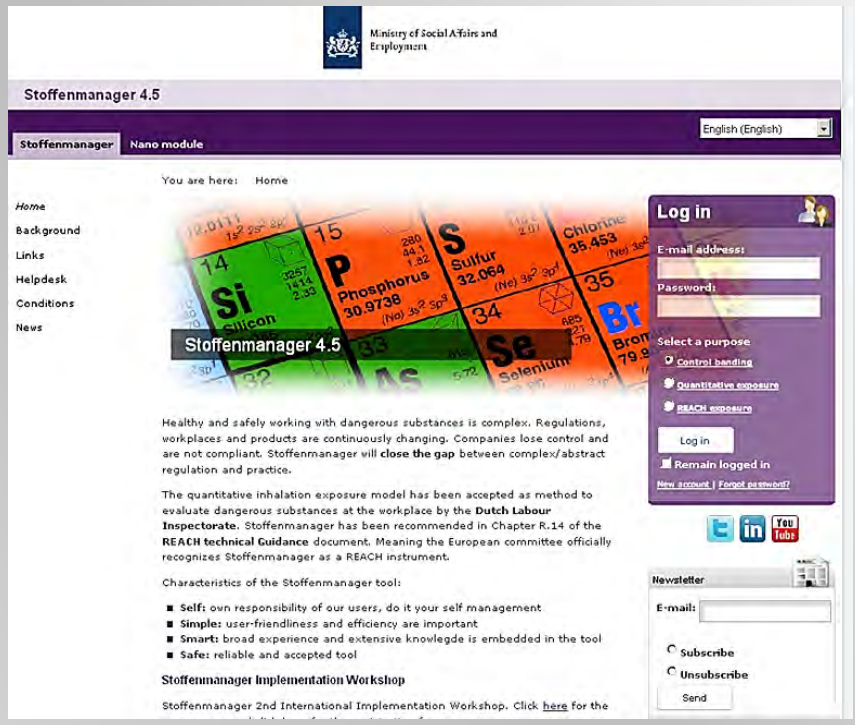
- R-Phrases
  - R-phrases are not available on all products and SDSs.
- Mixtures
  - Mixing two chemicals together
  - Cumulative effects
- Process emissions or derivatives
  - Welding fumes or silica dust
- Other hazards or exposure routes
  - Musculoskeletal disorders or skin contact
- Verify that controls work
  - Not using controls correctly
  - Evaluate that controls are working (i.e. sampling)

Risk Prioritization Model

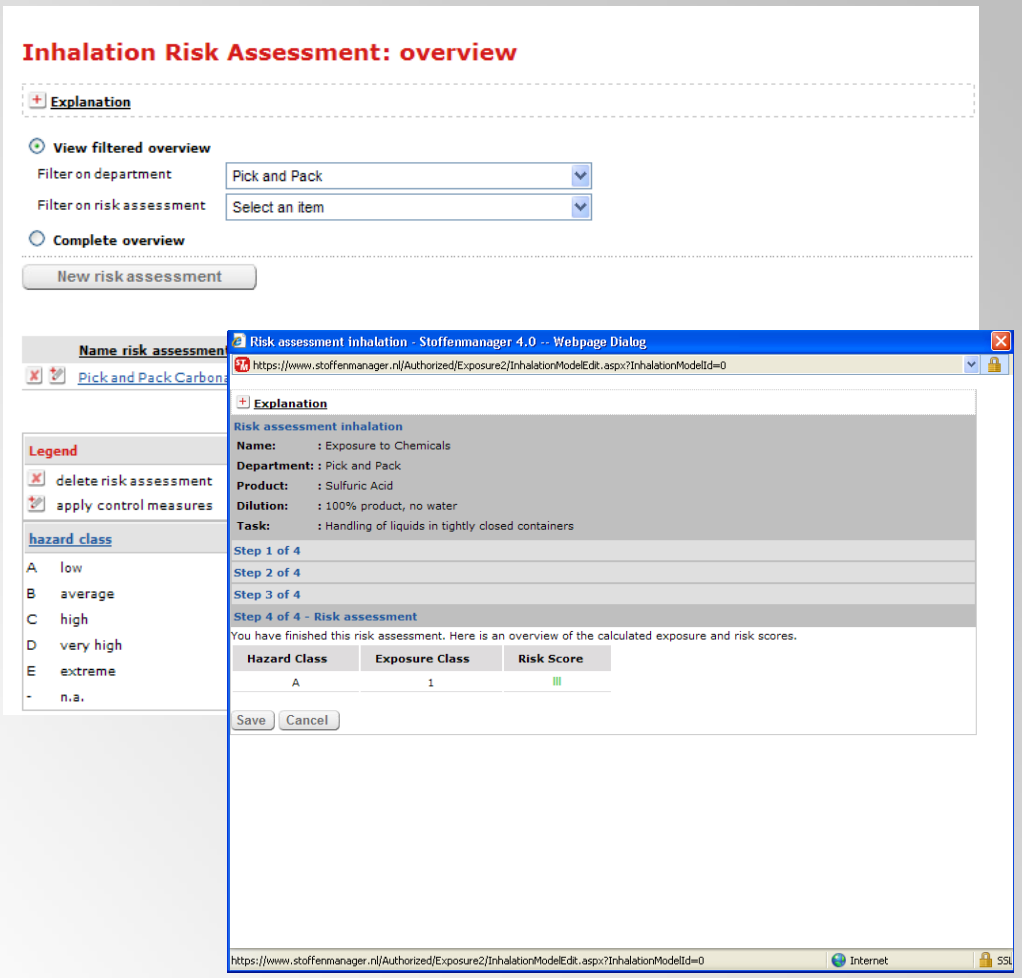
- Sometimes called “risk banding”
  - The user enters basic substance information (hazard) and exposure information
  - The results from the hazard and exposure band are combined to produce risk bands (aka priority bands)
  - Purpose is to guide the user to prioritize the workplace risks

Stoffenmanager

- Web-based control banding tool using an exposure process model
- Allows user to enter information about the product of interest and the worksite.
- Prioritizes exposure to these products through allocation into risk bands
- Must register with the site to enter your exposure information
- Site will save your previous entries
- Currently available in English and Dutch
- www.stoffenmanager.nl



Stoffenmanager 4.5



- Based on user input a hazard class and exposure class is evaluated.
- A risk score is calculated to assist in prioritization of risks.
- Permits the user to try to evaluate different controls and will calculate the impact the control has.
- Not for use with nanomaterials

Stoffenmanager Nano 1.0

Applies to nanomaterials that meet all of the following criteria:

- Particles are not *(water) soluble*
- The particles are purposely (synthetically) produced and not released as unintentional by-product (i.e. as a result of incomplete combustion)
- The size of the primary particle is smaller than 100 nm and/or the specific surface area of the nanopowder is larger than 60 m^2/g
- It concerns single particles as well as *agglomerates or aggregates* .

If the particle does not meet the above criteria, use Stoffenmanager 4.5.

Case Study using Stoffenmanager Nano 1.0

- Carbon nanotubes (CNT) are grown onto a fibrous material and then drawn through a growth chamber. The CNT-covered product is then wound onto a spool and placed into a bag for transport. The entire process takes place inside an enclosure. Twice daily (Monday through Friday) one operator is required to open the enclosure and uses an abrasive pad to remove any residual material and then wipes the area down with acetone. This cleaning process takes 45 minutes. General ventilation operates at greater than 8 air changes per hour and the air is HEPA filtered prior to exhaust outside the facility. The room volume is 250 m^3. No local exhaust ventilation is present when the enclosure is open. The employee wears nitrile gloves and a disposable lab coat with wrist cuffs.
- How would exposure change if the employee were to wear an air-purifying full-face particulate respirator equipped with stacked organic vapor/particulate (P-100) cartridges (P3L-European)?
- How would exposure change if the employee were to wet the product prior to cleaning?

The GoodNanoGuide

- Protected Internet site on occupational practices for the safe handling of nanomaterials
- Multiple stakeholders contribute, share and discuss information
- Modern, interactive, up-to-date

http://GoodNanoGuide.org

Case Study: GoodNanoGuide e-tool

http://www.goodnanoguide.com

NanoTech Industries turns graphite into nano-sized graphene platelets. The nano-graphene platelets (NGP) are removed from a dryer, and must be weighed and packaged for sale and distribution. Very small quantities of dried graphene platelets are produced, and must be carefully conserved when packaging. NGPs have unknown hazard characteristics but it is suspected that they may be respirable due to their small size.

- NGPs are removed from the drying cylinder and weighed on a benchtop scale.
- The employee weighs and transfers approximately 30g of NGP per batch, which takes approximately 20 minutes to complete.
- The employee performs this task 2 times a day, five days a week.

GoodNanoGuide Case Study

- What hazard group do graphene platelets fall into?
- What controls would you recommend to protect workers at NanoTech Industries?

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

Control Banding Nanotool

Requires calculation of a Severity and Probability score by answering questions about the bulk and the nanomaterial.

- Severity Score: Out of 100 points
  - 70 based on characteristics of the nanomaterial and 30 based on characteristics of the parent material
- Probability Score: Out of 100 points
  - Determine the extent which employees may be exposed to nanoscale materials

    Examples: amount used during task, dustiness/mistiness, number of employees with similar exposure, frequency of operation, and operation duration
- Risk level is determined using both Severity and Probability Scores.

Source: 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.

Control Banding Nanotool

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

Resources and NIOSH Contacts

General Information on Control Banding	
NIOSH Control Banding Topic Page	http://www.cdc.gov/niosh/topics/ctrlbanding/
COSHH Essentials	http://www.coshh-essentials.org.uk/
GoodNanoGuide	http://GoodNanoGuide.org
Stoffenmanager 1.0 Stoffenmanager Nano 4.0	https://www.stoffenmanager.nl/ http://nano.stoffenmanager.nl/
Control Banding (CB) Nanotool	http://controlbanding.net/

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The findings and conclusions in this presentation have not been formally reviewed by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.