Better Industrial Hygiene through Health Hazard and Control Banding Strategies

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Health Hazard Banding (HHB)

- A classification system used to assign materials into health hazard categories of increasing severity based upon their inherent pharmacological and toxicological properties.
Control Banding (CB)

- A system used to determine control measures (for example dilution ventilation, engineering controls, containment, etc.) based on health hazard bands and anticipated exposures.
Occupational Exposure Banding (OEB)

- Application of hazard and control banding in the assessment and management of workplace risks.
Modern Industrial Hygiene Pitfalls

- Decisions with limited data
- Poor understanding of statistical principles
- Outdated exposure limits
- “Bright line in the sand”
- Disparate end points
- No exposure limits for most chemicals
- Infrequent application of risk assessment
Scope of challenge to “design-out” chemical hazards

- ~21,000,000 commercially available chemicals
- 107,067 REACH* registrations (1-3-11) for >1000 tons production volume or those of high concern
- But...only ~ 500 PELs, ~ 650 RELs, ~ 125 WEELs, ~ 650 TLVs

*REACH – Registration, Evaluation, Authorization, and Restriction of Chemicals
Another approach?

Pharma model:

- Step 1. Hazard and control banding.
- Step 2. Occupational exposure limit and analytical method development.
- Step 3. Exposure monitoring.
- Step 4. Additional control and ongoing exposure and medical monitoring if warranted.
How can this be applied throughout industry?

- Step 1. Qualitative risk assessment (health hazard banding, professional judgment); implement controls
- Step 2. Toxicological reviews; exposure modeling and risk assessment; refine controls.
- Step 3. Tox testing/modeling; OELs; methods; exposure assessment; dose-response; refine controls.
- Step 4. Ongoing exposure assessment and medical monitoring; dose-response including complex scenarios; refine controls.
Hazard Assessment
- Identify and Define "Hazard Criteria"
  - Hazard Bands (OEBs)
  - Exposure Limits (OELs)
  - Skin Notations, ...

Exposure Risk Assessment
- Collect all relevant exposure information and assess exposure risk against "Hazard Criteria"

Exposure Management
- Define Controls & Programs Utilizing the Hierarchy of Controls

Anticipation + Recognition ➔ Evaluation ➔ Control + Confirm

Re-Evaluate as Required

Industrial Hygiene Process

Courtesy of ERAM Working Group
Risk Management Paradigms*

**Traditional Risk Management**

Hazard ➔ Exposure ➔ Control

**Control Banding Risk Management**

Hazard ➔ Control ➔ Exposure

*(control verification)*

*Keith Tait, Corporate Health & Safety, Pfizer - National Control Banding Workshop, Washington, DC, March 2005*
Risk Management Decision-Making Framework

Anticipate

Confirm

Recognize

Control

Evaluate

Documentation and Improvement

Source: Hoover et al., The Synergist, January 2011
HISTORICAL PERSPECTIVE
Background

Based on the NIH/CDC Biosafety Level model

- Assign chemicals into “categories” or “bands” based on their inherent properties
- Pre-assign safe handling procedures for each operation based on its exposure potential
- Control recommendations were based on success with compounds having similar characteristics
- Work environments, process controls, techniques, PPE
- Air monitoring results to support control levels
Pharmaceutical Drivers

- Concept evolved out of necessity in the pharmaceutical industry
- Late 1980s, increased specificity of drug candidates
  - Increased potency
- Industry had little experience developing OELs in the micro-nanogram/m$^3$
- Inadequate analytical method sensitivity
- Chemical synthesis and drug formulation processing equipment had traditional IH controls
Pharmaceutical Operations in the 80's
Performance-Based Exposure Control Limits (PB-ECLs)

- First described by Naumann et al. in 1996
- 4-band system proposed by Farris and Sussman from SafeBridge
- U.K. HSE COSHH Essentials (late 1990s)
- ILO International Chemical Control Toolkit (after 2004)
Framework for Control Banding

- Number of bands vary based on the different control approaches used in each company though the industry is gradually reaching consensus.
- Three to six-band models are in practice
  - 1:1 correlation (HHB:CB) or other variation?
- Systems evolve due to changes in manufacturing technology, containment options, and therapies.
Basis of HHBs

- Therapeutic dose
- Therapeutic class
- Toxicological effects
  - Acute Toxicity
  - Chronic Toxicity
  - Reproductive Toxicity
  - Genetic Toxicity
- Pharmacological effects
Factors Considered in Establishing an Occupational Exposure Limit (OEL)

- Toxicology studies in animals
- Epidemiology studies in humans
- Documented case histories of accidental exposures
- Available information from industrial & medical experience
- Similarity to other chemicals with established OEL
- Acute or chronic effects of exposure
- Sometimes we do not have sufficient data to set an OEL
“Hierarchy of Controls”
Substitution/Elimination
Engineering Controls
Administrative Controls
Personal Protective Equipment
General Design Concepts

- Greatest exposures generally occur when handling dry solids
  - Examples – weighing, transfer, mixing, charging of vessels, grinding, sieving, milling

- Handling as solutions, suspensions or emulsions is preferred

- Containment and ventilation controls utilized for highest risk operations with solids and aerosolized liquids
Control Bands

For each category, a control band/handling practice guideline is developed based on:

- Health hazard bands
- Exposure potential (scale of operations, dustiness, etc.)
- Containment capabilities of control devices
Hierarchy of Exposure Control Technology

LEVEL OF CONTROL (TWA*)

- **< 0.5 ug/m³**
  - Closed Operation - 4

- **< 5 ug/m³**
  - Barrier - 3B

- **20 - 100 ug/m³**
  - Directional Laminar Flow - 2

- **> 100 ug/m³**
  - Local Exhaust
  - General Ventilation - 1

Open Operation
COSHH ESSENTIALS
Overview of COSHH Essentials, the ILO Toolkit, and other Control Banding Models

Courtesy of:
Anne Bracker
Thomas J. Lentz, Ph.D., MPH
Donna Heidel

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.
CONTROL BANDING
What are HSE COSHH Essentials?

Control of Substances Hazardous to Health Essentials comprise an instrument designed by the U.K. HSE

... for small and medium size businesses

... for doing qualitative exposure assessments

... to provide guidance for achieving a recommended control level based on hierarchy of controls principles

(http://www.coshh-essentials.org.uk/)
COSHH Essentials
How is it used?
The small/medium enterprise (SME) operator uses a single-page check-list to determine..

- hazard rating from MSDS or IPCS card (R-phrases)
- quantity used (small, medium, large)
- physical form / characteristics (dust, vapor)
- target control level
- specific control guidance
- an action plan
## COSHH Essentials/Control Banding
### Overall Approach

<table>
<thead>
<tr>
<th>Health Exposure</th>
<th>Hazard Potential</th>
<th>Generic Risk Assessment</th>
<th>Control Approach (risk management)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substances allocated to hazard group using R-phrases</td>
<td>Substances allocated a dustiness or volatility band and a band for the scale of use</td>
<td>Combination of health hazard and exposure potential factors determine desired level of control</td>
<td>Type of approach needed to achieve adequate control</td>
</tr>
</tbody>
</table>
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, reproductive hazards)
    skin and eye hazard S
## Key concept: Risk phrases

### Hazard groups A-E (chemicals causing harm when breathed in)

<table>
<thead>
<tr>
<th>Group</th>
<th>Codes</th>
<th>Notes</th>
</tr>
</thead>
</table>
| **A** | R36  
R36/38  
R38 | And all substances that don’t have R-phrases in groups B-E |
| **B** | R20  
R20/21  
R20/21/22  
R20/22  
R21  
R21/22  
R22 | |
| **C** | R23  
R23/24  
R23/24/25  
R23/25  
R24  
R24/25  
R25  
R28  
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 | Carc cat 3 R40 |
| **D** | R26  
R26/27  
R26/27/28  
R26/28  
R27  
R27/28  
R28  
R48/23  
R48/23/24  
R48/23/24/25  
R48/23/25  
R48/24  
R48/24/25  
R48/25  
R60  
R61  
R62  
R63 | |
| **E** | Muta cat 3 R40  
R42  
R42/43  
R45  
R46  
R49 | |

**Least hazardous substances**

**more hazardous substances**

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

**Step 2B – How much is used?**

<table>
<thead>
<tr>
<th>AMOUNT</th>
<th>SOLID</th>
<th>LIQUID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>grams</td>
<td>milliliters</td>
</tr>
<tr>
<td>Medium</td>
<td>kilograms</td>
<td>liters</td>
</tr>
<tr>
<td>Large</td>
<td>tons</td>
<td>cubic meters</td>
</tr>
</tbody>
</table>
**COSH Essentials/ Control Banding**

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

*Similar matrix for categories of volatility based on the boiling point of substances and process operating temperatures.*
Step 3. Find the Control Approach

For some activities, processes, tasks, or jobs, specialists can identify that respiratory protective equipment (RPE), in combination with other control approaches, is always necessary. This makes a “fifth” approach.
Finding the Right Control Approach

Control Approach (Key):
- General Ventilation
- Engineering Control
- Containment
- Special

Dispersion Potential:
- Low dustiness or volatility
- Medium volatility
- Medium dustiness
- High dustiness or volatility

Amount:
- Large
- Medium
- Small

Hazard Groups:
- 'A'
- 'B'
- 'C'
- 'D'
- 'E'

Step 3
Step 4: Task Specific Control Guidance Sheets

Mixing (liquids)

Containment

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

Design and equipment
✓ The mixer should be fully enclosed and provided with effective seals on the lid, other access points and mixer drive shafts.
✓ Ensure the mixer is adequately vented to prevent pressure build-up.
✓ The mixer should be provided with liquid level and pressure indicators that are clearly visible.
✓ Consider the use of pressure relief valves and/or bursting discs for reactive materials.
✓ Do not allow entry to a closed mixer for cleaning or maintenance until the equipment has been isolated, made safe and the atmosphere checked for oxygen deficiency or toxic gases.
✓ Design the closed system to allow easy maintenance and cleaning.
✓ Keep the process equipment under negative pressure to prevent leakage.
✓ Discharge extracted air to a safe place away from doors, windows and air

This guidance sheet is aimed at employers to help them comply with the requirements of the Control of Substances Hazardous to Health Regulations 2002 (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 mixing medium and large quantities of liquids. 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.

Depending on the scale of work, releases into the atmosphere may be regulated within the pollution prevention and control (PPC) framework. You should consult your local authority or the

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Depending on the scale of work, releases into the atmosphere may be regulated within the pollution prevention and control (PPC) framework. You should consult your local authority or the
Sack emptying

Containment

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

Design and equipment
- Provide arrangements to stop and vacuum or wet clean the conveyor belt.
- Enclose the work area as much as possible - see diagram.
- Ensure an air flow 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 sew-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 need be.
- Design the system to avoid any maintenance.
- Where operational factors permit, keep the process equipment under negative pressure to prevent leakage.
- Exchange extracted air to a safe place away from floors, windows and air intakes.

Maintenance
- Ensure all equipment used in the task is maintained as advised by the supplier/manufacturer to ensure effective and efficient working order and good repair.
- Adopt a 'preventive' system for maintenance work.
- Follow any special procedures that are needed before the system is opened or closed, eg priming and cleaning.

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 once a year (see HSE publication HSG64).
- 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 work area regularly - once a week is recommended.
- Store packages/containers in a safe place (see HSG 101).
- Dispose of empty packages/containers safely.
- Fit bags in containers immediately after use.
- Deal with spills immediately.
- Don't clean up with a dry brush or compressed air. Use a vacuum cleaner or wet cleaning.

Personal protective equipment (PPE)
- Chemicals in the same group can damage skin and eyes. Encourage staff to rely on the skin and cause harm. See CES 100 and 101 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 required 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. Decisions on whether RPE is required should be taken on the day.

Training
- Check your employees on the harmful nature of the chemicals.
- Provide them with training on operating the process. Training procedures are given in the HSE manual on 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.
- Introduction to local exhaust ventilation HSG37: HSE Books 1993
  ISBN 0 7176 1100 2.
- Control Guidance sheets 301, 204, 342, S100 and S101.
Web tool

http://www.coshh-essentials.org.uk/
Case Study-
Task: Applying a Wiping Stain
- Satin Finish
- Applied with a rag
- Quantity: 1.5 liters
- Frequency: Six times a day for 30 minutes
- Room Temperature

- Current Controls: Nitrile Gloves
  Applied in a Flammable Spray Room
Material Safety Data Sheet

SECTION 1 PRODUCT AND COMPANY IDENTIFICATION

Original Satin Finish

Product Number(s): TB 6022

Company Identification
Waterlox Coatings Corp.
9608 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: 8-03-04

SECTION 2 COMPOSITION/ INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>CAS NUMBER</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stoddard Solvent</td>
<td>8052-41-3</td>
<td>&lt; 70.0% weight</td>
</tr>
<tr>
<td>1,2,4 - Trimethylbenzene</td>
<td>95-63-6</td>
<td>&lt; 5.0% weight</td>
</tr>
<tr>
<td>1,3,5 - Trimethylbenzene</td>
<td>108-67-8</td>
<td>&lt; 5.0% weight</td>
</tr>
<tr>
<td>Cobalt Naphthenate</td>
<td>61780-51-3</td>
<td>&lt; 1.0% weight</td>
</tr>
</tbody>
</table>

SECTION 3 HAZARDS IDENTIFICATION

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.
## Evaluating the task with quantitative industrial hygiene tools

<table>
<thead>
<tr>
<th>Component</th>
<th>TLV</th>
<th>OSHA PEL (USA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stoddard solvent</td>
<td>100 ppm</td>
<td>500 ppm</td>
</tr>
<tr>
<td>Trimethyl benzene (mixed isomers)</td>
<td>25 ppm</td>
<td>xxxxx</td>
</tr>
<tr>
<td>Cobalt Napthenate</td>
<td>xxxxx</td>
<td>xxxxx</td>
</tr>
</tbody>
</table>

**Cost:** $46-$65/ sample + IH fee
Evaluating the task with “Best Practices” and “Generic Control Banding”
DIRECT ADVICE

Please select from one of the options below.

Then click 'Go' at the bottom of the page. It will give you a list of related processes, tasks or services from which you can go straight to the appropriate guidance sheets. You may return to this page as many times as you like without needing an assessment code.

- Flour milling and craft bakery
- Foundry work
- Rubber making
- Woodwork
- Printing
- Welding
- Metalworking fluids

Is there Best Practice Advice?
DIRECT ADVICE

Please select one or MORE of the options below.

Then click 'Go' at the bottom of the page. It will give you a list of related processes, tasks or services from which you can go straight to the appropriate guidance sheets. You may return to this page as many times as you like without needing an assessment code.

Sawing
- Bandsaws
- Circular bench saws
- Cross-cut saws

Sanding
- Hand-held sanding machines
- Sanding machines

Shaping
- Overhead and CNC routers
- Vertical spindle moulders

Other tasks
- Furniture assembly
- Stand-alone dust collectors (occasional use)

Select all
Finishing operations pose a wide range of health and safety hazards due to the volume and physical properties of the chemicals involved. A complete discussion of this topic is beyond the scope of this eTool; however, a general discussion of common hazards and related control measures are provided. To best protect employees from the chemical hazards related to finishing operations, identify the specific chemicals in use within the facility and consult the appropriate OSHA standards to determine required controls. See the additional references section for a list of the OSHA standards likely to apply to finishing operations.

> General Hazards/Solutions
> Hazard Communication
> Personal Protective Equipment
Possible Solutions:

**Engineering Controls**

- When feasible, use automated systems for applying coatings and adhesives. Automated systems should be ventilated.

- Substitute the traditional solvent-based coatings and adhesives with coatings and adhesives that are less toxic. Hot melt, heat seal, aqueous-based, and polyvinyl acetate adhesives are good, less-toxic alternatives to solvent-based adhesives. Higher-solids nitrocellulose, aqueous-based, ultraviolet-cured, and polyester/polyurethane coatings also are less toxic than solvent-based coatings.

- Provide adequate local exhaust ventilation for all coating and gluing processes. This includes manual spraying, rolling, and brushing operations, automated coating processes, and dip coating. Manual spray operations should be performed in a spray booth or a separate, ventilated spray area. Dip coating should be ventilated with an enclosure or capture hood. Consult the OSHA standard on dip coating (open surface tanks), 1910.122-126, for detailed requirements on dipping operations.

- The OSHA standard for spray finishing operations, 1910.107, provides detailed requirements for the design and construction of spray booths and rooms, air filters, velocity and air flow requirements, and the (make-up) air supplied to the booth. It is important to maintain the proper air flow in a spray booth. Excessive air pressure decreases the efficiency of the operation, wastes material, and may cause a backlash of vapors and overspray into adjacent work areas. Dirty air filters can decrease the air flow in the booth. Ensure that filters are cleaned and replaced as needed. Although these provisions are designed to prevent the occurrence of a fire or explosion in spray finishing operations, they also assist in protecting workers from the health hazards of the chemicals used in the operation by removing the chemicals from the atmosphere.

- Employers shall provide employees with effective information and training on hazardous chemicals. 1910.1200(h)(1)

Controls designed to prevent fire and explosion resulting from the use of flammable and combustible materials in woodworking operations are discussed in the Fire and Explosion section of this eTool. The controls discussed in this section generally are also applicable to finishing.
Evaluating Task with the Generic Control Banding Model

- Step 1: Identify the hazardous substances
- Step 2: Select a “health hazard group”
- Step 3: Determine the exposure potential
## Control Banding Worksheet

Task/Unit Operation: **Applying a Wiping Stain**

<table>
<thead>
<tr>
<th>Health Hazard</th>
<th>Exposure Potential</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical/Product (CAS#)</strong></td>
<td><strong>R Phrase(s)</strong></td>
<td><strong>Amount</strong></td>
</tr>
<tr>
<td>Satin Finish</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hazard Group</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>☐</td>
<td>☐</td>
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Are current controls adequate? ____________________________
SUMMARY OF USER INPUT

Your assessment code : GE35138517
Process name : wiping stain
Task : Surface coating

Congratulations! You have now input all the information needed for COSHH Essentials to carry out a risk assessment for 1 chemical. You should now print off the control guidance sheets offered to you, check that your controls meet those recommended and follow the actions suggested.

Below is a summary of the information you have input. If you think you have made a mistake or you wish to change any of the information, please click here to edit the information on this task.

To obtain more details on the summary, click on any of the terms below.

| Chemical or product name : satin finish | 
|----------------------------------------|----------------|
| Reaches : R22, R35/57/38, R66, R67    | 
| State : Liquid                         | 
| Operating temperature : 25 °C         | 
| Boiling point : 150 °C                | 
| Hazard group : C                       | 
| Skin hazard : Yes                      | 
| Quantity used : Medium                 | 
| How many times a day? : 6 times a day  | 
| How long does the task take? : 30 minutes |
ADVICE ON HOW TO PROTECT YOURSELF AND OTHERS

Your assessment code: GE35138517
Process name: wiping stain
Task: Surface coating

Having assessed the 1 chemical used in this task, COSHH Essentials has calculated that use control approach "Engineering Control". This is based on the highest hazard found.

+ Substitution

The guidance sheets listed below give you advice on areas such as design and equipment, maintenance, examination and testing, cleaning and housekeeping, personal protective equipment, training and supervision.

You should now print off the guidance sheets and also print off the summary of your assessment for your records. The summary will also give you important information about what you should do to put the advice into practice and other action you may need to take.

Please note: The summary and guidance sheets provided below are PDF files. To view these files, you have to have Adobe® Acrobat Reader installed. If you do not have Acrobat Reader installed, click the button to download and install the latest version. THIS SOFTWARE HAS BEEN CHECKED FOR VIRUSES AND IS COMPLETELY SAFE TO DOWNLOAD.

Download the summary of your assessment here:

Recommended control approach: Engineering Control

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Guidance Sheet Title</th>
<th>Number</th>
<th>Download</th>
</tr>
</thead>
<tbody>
<tr>
<td>General tasks</td>
<td>Local exhaust ventilation</td>
<td>G200</td>
<td></td>
</tr>
<tr>
<td>General tasks</td>
<td>Laminar flow booth</td>
<td>G202</td>
<td></td>
</tr>
<tr>
<td>Surface coating</td>
<td>Spray painting</td>
<td>G221</td>
<td></td>
</tr>
</tbody>
</table>

Your task involves Chemicals causing harm via skin contact. Hence the following Guidance Sheets are also recommended:

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Guidance Sheet Title</th>
<th>Number</th>
<th>Download</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>General advice</td>
<td>S100</td>
<td></td>
</tr>
</tbody>
</table>
Evaluate and Discuss

Do you agree with the Model?
Are current controls adequate?
What would happen to risk assessment with:
  less hazardous chemical?
  lower quantity?
  spray application?
Would it make more sense to go directly to Best Practices?
When would air sampling be appropriate?
Does the Model Work?

• Validation: Does the model predict the appropriate level of control?
  – Target exposure for hazard band was lower than the OEL 98% of the time (Brooke, 1998)
  – Measured data lower than model for most processes except for operations involving small quantities of volatile chemicals in settings with dilution ventilation (Tischer, 2003)
  – Small safety margins for the hazard bands that included high-potency chemicals (need to evaluate effectiveness of controls). [Jones and Nicas 2004]
OTHER TOOLKITS
International Chemical Control Toolkit


International Chemical Control Toolkit

Introduction

The International Chemical Control Toolkit outlines a scheme for protection against harmful and dangerous chemicals in the workplace. It is designed for small and medium sized enterprises (SMEs) in developing countries. The current pages are intended to assist you in following that scheme.

A procedure is described for finding relevant instructions (guidance sheets) for the safe handling of a substance under given conditions.

For some frequently used solvents a shortcut is provided via Common solvents, while pesticides users have access to a list of control sheets compiled under Pesticides.

Information on respiratory protection equipment (RPE) can be obtained under Respirators and other safety and environmental risks are dealt with in sections Safety issues and Environment, respectively.

A complete list of guidance sheets is available at Guidance sheets, and the complete toolkit may be seen at.

Last but not least, we should like to emphasize the draft nature of the current compilation. We count on your comments in making it more helpful to those who decide to use it. Thank you in advance.

Updated by AS (CIS), approved by PB (SafeWork). Last modification: 20.06.2006.

For further information please contact the Programme on Safety and Health at Work and the Environment (SafeWork).

Tel: +41 22 799 6716, Fax: +41 22 799 6579 or E-mail: safework@ilo.org

SafeWork: I Tco (PROTECTION) Home | SafeWork Home | Publications |
GTZ Chemical Management Guide

- Basic concepts for risk assessment
- Description of control approaches
- Effect use Safety Data Sheets
- Risk phrases for hazardous substances
- Safety phrases for hazardous substances
- Symbols used for labeling hazardous substances
Other International Models

• ANSES (France) – Control Banding Tool for Nanomaterials (http://afsse.fr )

• Stoffenmanager 4.0 (the Netherlands) – Work Safe with Hazardous Substances (www.stoffenmanager.nl)

• Baua (German) Model – Easy-to-use workplace control scheme for hazardous substances (www.baua.de )
Netherlands – Generating company specific OELs

- 2 stage process
  - Derivation of health based OEL
  - Application of workplace factors

- Automated tool at www.veiligwerkenmetchemischestoffen.nl (in Dutch)
Netherlands – Generating company specific OELs

1. Public OEL
2. SCOEL, Health Council
3. International / Producer OEL
4. Derive OEL from data
5. Apply workplace assessment factors
6. Company OEL
Netherlands – Use of control banding in setting limit values

- Risk phrases from European Union Classification and Labelling scheme
- Division from German guidelines for dangerous substances (TRGS-440)
  - 4 Hazard classes
  - Correlates best with current OEL’s
- 95-percentile of OEL per hazard class used as Kick-off limit values
## Netherlands – Hazard Band “Kick-off limit values”

<table>
<thead>
<tr>
<th>Hazard class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-phrases</td>
<td>36, 37, 38, 65, 66, 67</td>
<td>20, 21, 22, 34, 41, 62, 63, 64</td>
<td>23, 24, 25, 29, 31, 33, 35, 40, 42, 43, 60, 61, 68</td>
<td>26, 27, 28, 32, 45, 46, 49</td>
</tr>
<tr>
<td>Kick-off limit values</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas &amp; Vapour (ppm)</td>
<td>4</td>
<td>0,2</td>
<td>0,01</td>
<td>0,001</td>
</tr>
<tr>
<td>Aerosols (mg/m3)</td>
<td>0,24</td>
<td>0,06</td>
<td>0,02</td>
<td>0,01</td>
</tr>
</tbody>
</table>
Examples of Control Banding Activities in the United States

- OSHA Proposed Silica Standard
- Control banding for engineered nanomaterials
- Control banding for exposures to hexavalent chromium during welding
- NIOSH, AIHA, and ACGIH Publications
## Figure 1. Risk level (RL) matrix as a function of severity and probability scores.
Control bands are based on overall risk levels.

<table>
<thead>
<tr>
<th>Probability Score</th>
<th>Extremely Unlikely (0–25)</th>
<th>Less Likely (26–50)</th>
<th>Likely (51–75)</th>
<th>Probable (76–100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High (76–100)</td>
<td>RL 3</td>
<td>RL 3</td>
<td>RL 4</td>
<td>RL 4</td>
</tr>
<tr>
<td>High (51–75)</td>
<td>RL 2</td>
<td>RL 2</td>
<td>RL 3</td>
<td>RL 4</td>
</tr>
<tr>
<td>Medium (26–50)</td>
<td>RL 1</td>
<td>RL 1</td>
<td>RL 2</td>
<td>RL 3</td>
</tr>
<tr>
<td>Low (0–25)</td>
<td>RL 1</td>
<td>RL 1</td>
<td>RL 1</td>
<td>RL 2</td>
</tr>
</tbody>
</table>

Control bands by risk level: RL 1: General ventilation; RL 2: Fume hoods or local exhaust ventilation; RL 3: Containment; RL 4: Seek specialist advice.
The exposure assessment tool is a guideline, based on hexavalent chromium exposure monitoring results collected by industrial hygienists at the University of Washington Field Research and Consultation Group, to support weld shops with objective data to evaluate potential hazards.
Dow/WEEL-Health Hazard Banding (HHB) IHG Matrix

- Dow Chemical utilizes a matrix developed & validated by the AIHA WEEL Committee (adapted from pharma HHBs); used to evaluate the relative toxicity endpoints.

- This matrix uses the toxicity data dose-response data found in a compendium of toxicity studies and summarizes the most pertinent health effects.

- It is a screening Hazard Banding tool used to help established Dow’s Industrial Hygiene Guidelines (IHG)
Health Hazards to Consider:

- Acute Toxicity
- Skin Corrosion/Irritation
- Serious Eye Damage/Eye Irritation
- Respiratory or Skin Sensitization
- Germ Cell Mutagenicinity
- Carcinogenicity
- Reproductive Toxicity
- Target Organ Systemic Toxicity – Single & Repeated Dose
<table>
<thead>
<tr>
<th>Study</th>
<th>Classification:</th>
<th>Virtually Non-Toxic</th>
<th>Low Toxicity-Irritating (Xi)</th>
<th>Moderate Toxicity - Harmful (Xn)</th>
<th>Toxic (T)</th>
<th>High Toxicity (T+)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Acute Oral Toxicity (Rat oral LD50)</td>
<td>No Data</td>
<td>&gt;2,000 mg/kg</td>
<td>300-2,000 mg/kg</td>
<td>50-300 mg/kg</td>
<td>5-50 mg/kg</td>
<td>&lt;5 mg/kg</td>
</tr>
<tr>
<td>Acute toxicity (Rat inhalation LC50)</td>
<td>&gt;10,000 ppm</td>
<td>&gt;10,000 ppm</td>
<td>1000-10,000 ppm</td>
<td>100-1000 ppm</td>
<td></td>
<td>1-100 ppm Consider STEL or Ceiling</td>
</tr>
<tr>
<td>Sensory irritation - (RD50) (in mice)</td>
<td>&gt;3,000 ppm or μg/m3</td>
<td>&gt;3,000 ppm or μg/m3</td>
<td>300-3000 ppm or μg/m3</td>
<td>30-300 ppm or μg/m3</td>
<td></td>
<td>1-30 ppm or μg/m3 Consider STEL or Ceiling</td>
</tr>
<tr>
<td>Skin Absorption (Dermal LD50 in rabbits) Covered (occluded) Open</td>
<td>&gt; 2000 mg/kg</td>
<td>&gt;2000 mg/kg</td>
<td>1000-2000 mg/kg - Add &quot;Skin&quot; Notation</td>
<td>100 - 1000 mg/kg - Add &quot;Skin&quot; Notation</td>
<td></td>
<td>&lt;100 mg/kg - Add &quot;Skin&quot; Notation and possibly additional warning statement with asterisk</td>
</tr>
<tr>
<td>Eye Irritation</td>
<td>mild to moderate</td>
<td>moderate to severe</td>
<td>severe but not corrosive</td>
<td>&quot;DOT Corrosive&quot;</td>
<td>&quot;DOT Corrosive&quot;</td>
<td></td>
</tr>
<tr>
<td>Skin Irritation or DOT Corrosive</td>
<td>mild to moderate</td>
<td>moderate to severe</td>
<td>severe to corrosive - &quot;DOT Corrosive&quot; - Add &quot;Skin&quot; Notation</td>
<td>&quot;DOT Corrosive&quot; - Add &quot;Skin&quot; Notation</td>
<td>&quot;DOT Corrosive&quot; - Add &quot;Skin&quot; Notation</td>
<td></td>
</tr>
<tr>
<td>Irritation threshold (μg/m³ or ppm) note: 1 microgram = 0.001 milligram (May be in mice, rats or human volunteers)</td>
<td>&gt;1000</td>
<td>100-1000</td>
<td>10-100</td>
<td>1-10 Consider STEL or Ceiling depending on severity</td>
<td>&lt;1 Consider STEL or Ceiling depending on severity</td>
<td></td>
</tr>
<tr>
<td>Warning properties / odor threshold</td>
<td>good (mild reversible effects such as slight irritation, odor)</td>
<td>good (mild reversible effects such as slight irritation, odor)</td>
<td>fair to none (no biological effect noticeable or no odor at an effect level)</td>
<td>poor to none (e.g. odor threshold well above toxic effects of concern)</td>
<td>poor to none (e.g. odor threshold well above toxic effects of concern)</td>
<td></td>
</tr>
</tbody>
</table>

Note: 1 microgram = 0.001 milligram.
<table>
<thead>
<tr>
<th>Classification:</th>
<th>Virtually Non-Toxic (X0)</th>
<th>Low Toxicity-Irritating (Xn)</th>
<th>Moderate Toxicity - Harmful (Xn)</th>
<th>Toxic (T)</th>
<th>High Toxicity (T+)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Study Criterion</td>
<td></td>
<td>No Data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target organ toxicity NOEL or NOAEL</td>
<td>&gt;1000 ppm</td>
<td>&gt;1000 ppm</td>
<td>100-1000 ppm</td>
<td>10-100 ppm</td>
<td>1-10 ppm</td>
</tr>
<tr>
<td>Adjust up a category for LOAELs</td>
<td>&gt;100 ppm</td>
<td>&gt;10 ppm</td>
<td>1-10 ppm</td>
<td>0.1-1 ppm</td>
<td>&lt;0.1 ppm</td>
</tr>
<tr>
<td>Severity of target organ toxicity Is the effect serious, non-reversible or lethal?</td>
<td>severity of the toxicity can push the above NOEL into a higher cell</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic and Subchronic</td>
<td>Repro/dev tox NOEL or NOAEL note: 1 microgram = 0.001 milligram</td>
<td>&gt;300 mg/kg/d</td>
<td>30-300 mg/kg/d</td>
<td>3-30 mg/kg/d</td>
<td>&lt;0.3 mg/kg/d</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;30,000 ppm or ug/m3</td>
<td>3000-30,000 ppm or ug/m3</td>
<td>300-3000 ppm or ug/m3</td>
<td>&lt;30 ppm or ug/m3</td>
</tr>
<tr>
<td>Genetox</td>
<td>negative</td>
<td>equivocal (some positive and some negative in vitro)</td>
<td>likely / limited or based on in vitro (cells, cultures, bacterium)</td>
<td>positive Weight of Evidence including in vivo (DNA adducts, evidence of cell damage or lethality where the whole system does not detoxify the genetic effects)</td>
<td>positive Weight of Evidence and potent</td>
</tr>
<tr>
<td>Cancer dose-NOEL/NOAELs</td>
<td>&gt;300 mg/kg/d</td>
<td>30-300 mg/kg/d</td>
<td>3-30 mg/kg/d</td>
<td>0.3-3 mg/kg/d</td>
<td>&lt;0.3 mg/kg/d</td>
</tr>
<tr>
<td></td>
<td>&gt;30,000 ppm or ug/m3</td>
<td>3000-30,000 ppm or ug/m3</td>
<td>300-3000 ppm or ug/m3</td>
<td>30-300 ppm or ug/m3</td>
<td>&lt;30 ppm or ug/m3</td>
</tr>
<tr>
<td>Carcinogenicity potential</td>
<td>severity of the toxicity can push the above NOEL into a higher cell</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OEL</td>
<td>OEL range (μg/m³ and ppm) note: 1 microgram = 0.001 milligram</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥1000</td>
<td>≥100, &lt;1000</td>
<td>≥10, &lt;100</td>
<td>≥1, &lt;10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skin notation (see results from Acute Section)</td>
<td>No</td>
<td>Yes - “Skin”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notations</td>
<td>Dermal Sensitization Notation (Reports of contact or vapor causing sensitization or reports of Guinea Pig maximization or Local Lymphnode Assay positive results)</td>
<td>No</td>
<td>Yes - DSEN</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Respiratory Sensitization Notation (Reports in humans or case studies, or medical surveillance of elicitation of IgE antibodies in blood)</td>
<td>No</td>
<td>Yes - RSEN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Food flavoring example

- In 2000, bronchiolitis obliterans diagnosed in former workers of a microwave popcorn plant in Jasper, Missouri associated with exposure to diacetyl
- 2,3 pentanedione substitution
- NIOSH draft criteria document establishes RELs for both compounds
- Other alpha dicarbonyl compounds?
1-Bromopropane example

- An environmentally-acceptable replacement for PERC (perchloroethylene) and other chlorofluorocarbons, but....
- Worker exposure can result in nervous system disorders, and...
- There is evidence of reproductive and developmental effects in animals
- Efforts underway to include occupational health considerations into the selection of environmental alternatives

Are there other alternatives that meet environmental goals while assuring the safety and health of the workers?
NIOSH DRAFT Criteria

• Criteria include qualitative, semi-quantitative, and quantitative data for each toxicological endpoint
  – Acute toxicity
  – Skin corrosion/irritation
  – Serious eye damage/eye irritation
  – Respiratory and skin sensitization
  – Germ cell mutagenicity
  – Carcinogenicity
  – Specific target organ toxicity, both single and repeated exposure
  – Reproductive toxicity
### NIOSH DRAFT Examples of Qualitative Criteria

<table>
<thead>
<tr>
<th>Band</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal Word</strong></td>
<td>Warning</td>
<td>Warning</td>
<td>Danger</td>
<td>Danger</td>
<td>Danger</td>
</tr>
<tr>
<td><strong>OEL Ranges</strong></td>
<td>( &gt; 1,000 \mu g/m^3 )</td>
<td>( &gt; 100 \text{ and } &lt; 1,000 \mu g/m^3 )</td>
<td>( &gt; 10 \text{ and } &lt; 100 \mu g/m^3 )</td>
<td>( &gt; 1 \text{ and } &lt; 10 \mu g/m^3 )</td>
<td>( &lt; 1 \mu g/m^3 )</td>
</tr>
<tr>
<td>( &gt; 1000 \text{ ppm} )</td>
<td>( &gt; 100 \text{ - } &lt; 1000 \text{ ppm} )</td>
<td>( &gt; 10 \text{ - } &lt; 100 \text{ ppm} )</td>
<td>( &gt; 1 \text{ - } &lt; 10 \text{ ppm} )</td>
<td>( &lt; 1 \text{ ppm} )</td>
<td></td>
</tr>
<tr>
<td><strong>Examples of Health Outcomes and Potency Considerations</strong></td>
<td>Minor, reversible health effects occurring at high doses. Skin and eye irritation.</td>
<td>Reversible organ toxicity, skin and eye corrosion (reversible), possible dermal sensitizer at high doses.</td>
<td>Irreversible organ toxicity at high doses, irreversible skin and eye corrosion, dermal sensitizer at moderate doses.</td>
<td>Irreversible organ toxicity at low doses, <em>in vivo</em> genotoxicity, dermal sensitizer at low doses, evidence of mutagenicity, potential developmental and reproductive toxicants.</td>
<td>Human carcinogens at low doses, respiratory sensitization</td>
</tr>
<tr>
<td><strong>Example GHS Hazard Statements and Hazard Category</strong></td>
<td>May cause drowsiness or dizziness</td>
<td>Harmful if inhaled (4). Harmful in contact with skin (4).</td>
<td>Toxic if inhaled (3). Toxic in contact with skin (3). Suspected of causing cancer (2). May cause damage to organs (2)</td>
<td>Fatal if inhaled (2). Fatal in contact with skin (1). Causes damage to organs (1). May cause cancer (by route of exposure)—1A. May cause allergy or asthma symptoms or breathing difficulties if inhaled (1A resp.). Known human reproductive toxicant (1A or 1B). Causes damage to organs through prolonged or repeated exposure (1)</td>
<td>Fatal if inhaled (1). Fatal in contact with skin (1). May cause cancer (by route of exposure)—1A. May cause allergy or asthma symptoms or breathing difficulties if inhaled (1A resp.). Known human reproductive toxicant (1A). Causes damage to organs through prolonged or repeated exposure (1)</td>
</tr>
</tbody>
</table>
Chemical for OEB

Available OEL? yes
- No OEB necessary

Available OEL? no

Criteria available? no
- Band C default assigned

Criteria available? yes

Band E criteria? yes
- Band E assigned

Band E criteria? no

Band D criteria? yes
- Band D assigned

Band D criteria? no

Tier 1 (qualitative)
Bands C, D, & E

Tier 2
Can Band A or B be considered?

Establish Total Determinant Score (TDS)

Does TDS exceed threshold for minimum, quality dataset? no
- Data insufficient for OEB, “C” default band

Does TDS exceed threshold for minimum, quality dataset? yes
- Establish OEB

TDS reflects the availability of qualitative info and/or quantitative data for each endpoint under consideration. Endpoint scores include data relevance and quality factors. TDS is the sum of the endpoint scores.

Courtesy of George Holdsworth
Examples

**1-bromopropane**
- Signal word: danger
- Hazard Category Repro 1B
- H360FD: May damage fertility or the unborn child
  - OSHA-GHS: Presumed human reproductive toxicant
- H373: May cause damage to organs through prolonged or repeated exposure (STOT-RE-2)
- H319: Causes serious eye irritation
- H335: May cause respiratory irritation
- H315: Causes skin irritation
- H336: May cause drowsiness or dizziness
- **Band D: (1-10 ppm)**
- TLV: 10 ppm

**Diacetyl**
- Signal word: danger
- Hazard Category STOT-RE 1
- H331: Toxic if inhaled
- H302: Harmful if swallowed
- H315: Causes skin irritation
- H318: Causes serious eye damage (category 1)
- H335: May cause respiratory irritation
- **Band E: (< 1 ppm)**
- NIOSH draft REL: 5 ppb
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)
Other Publications

• AIHA Publication (2007)
  — *Guidance for Conducting Control Banding Analyses*

• ACGIH Publication (2008)
  — *Control Banding: Issues and Opportunities*

• *Control Banding* — D. Zalk (2010)
Emerging Issues – New applications?

• Engineered nanomaterials
• Extremely low frequency electromagnetic fields (ELF EMF)*
• Integration with *Prevention through Design (PtD)*

*3-3000 Hz associated with AC electricity
Consequences of new regulations

- EU REACH requires producers / importers of substances to device:
  - Derived no effect levels (DNELs)
  - Safe working practices for all hazardous substances
  - Fully implemented in 2018

- Globally Harmonized System
  - New set of hazard classification
  - New grouping of hazard sentences for control banding
  - Fully implemented in 2015
STRATEGIES TO VERIFY CONTROLS
Methods to evaluate and verify controls

- Professional judgment (qualitative)
- Modeling
- Measurements and testing of controls
- Exposure monitoring
  - Surrogates
  - Chemicals of interest
<table>
<thead>
<tr>
<th>CONTROL BAND</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>?</td>
<td>!</td>
<td>!!</td>
<td>!!!</td>
</tr>
<tr>
<td>2</td>
<td>$</td>
<td>?</td>
<td>!</td>
<td>!!</td>
</tr>
<tr>
<td>3</td>
<td>$$</td>
<td>$</td>
<td>?</td>
<td>!</td>
</tr>
<tr>
<td>4</td>
<td>$$$</td>
<td>$$</td>
<td>$</td>
<td>?</td>
</tr>
</tbody>
</table>
Acceptance Criteria

- What does an acceptable exposure distribution look like for a population? . . . For an individual?
- What statistical measure and/or acceptance criteria should be used?
Statistical Terms - Review

- Arithmetic (µ or \( \bar{x} \)) v. Geometric Mean (GM)
- 95\textsuperscript{th} Percentile (\( X_{0.95} \))
- Confidence interval (CI)
  - Upper Confidence Limit (UCL)
Conventional Statistics – GM, $X_{0.95}$, UCL
Typical Statistical Assumptions

- Homogeneous data set
- Random data
- Normal / lognormal data
Common acceptance criteria in industrial hygiene

- One (or more) samples looked fine
- Calculated $X_{0.95} < \text{OEL}$
- UCL of $X_{0.95} < \text{OEL}$
- UCL of $\bar{X} < \text{OEL}$
- Posterior Bayesian probability of exceeding OEL $< 5\%$
### Table 1. Integrated Methylene Chloride Sampling Results at [Redacted], August 2, 2010

*Exposure Limits: PEL = 25 ppm (TWA), Action Level = 12.5 ppm (TWA)*

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Location and Duration</th>
<th>Sampling Result ppm</th>
<th>8 Hour Time Weighted Average Result*, ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>XH5654</td>
<td>(operator gluing plastic parts), 438 minutes</td>
<td>13.0</td>
<td>13.0 (10.6, 15.4)*</td>
</tr>
<tr>
<td>XH5650</td>
<td>Field Blank</td>
<td>LOD, &lt; 5 µg</td>
<td>n/a</td>
</tr>
</tbody>
</table>

### Table 1. Integrated Methylene Chloride Sampling Results at [Redacted], January 20, 2011

*Exposure Limits: PEL = 25 ppm (TWA), Action Level = 12.5 ppm (TWA)*

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Location and Duration</th>
<th>Sampling Result ppm</th>
<th>8 Hour Time Weighted Average Result, ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>XU3851</td>
<td>(operator gluing plastic parts), 489 minutes</td>
<td>12.0</td>
<td>12.0 (9.2, 14.8)*</td>
</tr>
<tr>
<td>XU3858</td>
<td>Field Blank</td>
<td>39 µg**</td>
<td>n/a</td>
</tr>
<tr>
<td>Date</td>
<td>Area</td>
<td>Chemical</td>
<td>% of OEL</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------</td>
<td>---------------------</td>
<td>----------</td>
</tr>
<tr>
<td>3/16/2011</td>
<td>Flake Screen/Jetmill</td>
<td>Respirable dust</td>
<td>32.4%</td>
</tr>
<tr>
<td>3/15/2011</td>
<td>Powder screening</td>
<td>Respirable dust</td>
<td>43.7%</td>
</tr>
<tr>
<td>3/16/2011</td>
<td>Classifying</td>
<td>Respirable dust</td>
<td>29.9%</td>
</tr>
<tr>
<td>Date</td>
<td>Area</td>
<td>Chemical</td>
<td>% of OEL</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>3/15/2011</td>
<td>Wash Vessel rm.</td>
<td>Methanol</td>
<td>151%</td>
</tr>
<tr>
<td>3/15/2011</td>
<td>Wash Vessel rm.</td>
<td>Methanol</td>
<td>70.7%</td>
</tr>
<tr>
<td>3/15/2011</td>
<td>Wash Vessel rm.</td>
<td>Methanol</td>
<td>54.3%</td>
</tr>
<tr>
<td>Date</td>
<td>Area</td>
<td>Chemical</td>
<td>% of OEL</td>
</tr>
<tr>
<td>------------</td>
<td>----------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>3/15/2011</td>
<td>Field Blank</td>
<td>Ammonia</td>
<td>n/a</td>
</tr>
<tr>
<td>3/15/2011</td>
<td>7000 Upper</td>
<td>Ammonia</td>
<td>1.6%</td>
</tr>
<tr>
<td>3/16/2011</td>
<td>Metal Recovery</td>
<td>Ammonia</td>
<td>4.1%</td>
</tr>
<tr>
<td>3/15/2011</td>
<td>7000 Upper</td>
<td>Ammonia</td>
<td>4.9%</td>
</tr>
<tr>
<td>3/15/2011</td>
<td>Metal Recovery</td>
<td>Ammonia</td>
<td>1.7%</td>
</tr>
</tbody>
</table>
One (or more) samples looked fine
One (or more) samples looked fine
One (or more) samples looked fine
Low Exposure Values

- 3 consecutive random samples < 0.1 x OEL (and none over 0.1 x OEL!) are a good indicator that $X_{0.95} < \text{OEL}$
- Even 1 random sample, but preferably 2 random samples < 0.01 x OEL are a good indicator that $X_{0.95} < \text{OEL}$
- For larger, uncensored data sets and for exposures closer to the OEL, use statistical tools
• Statistical rule of thumb: “The width of the confidence interval decreases rapidly until 12 observations are reached and then decreases less rapidly”.


• Altemose rule of thumb: “If you don’t have 5 or 6 samples, you’re kidding yourself if you calculate statistics, even with those new-fangled Bayesian statistics”.

<table>
<thead>
<tr>
<th>No. samples</th>
<th>Frequency under-estimate GSD</th>
<th>Frequency under-estimate X95 by 2x</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>63%</td>
<td>30%</td>
</tr>
<tr>
<td>6</td>
<td>58%</td>
<td>15%</td>
</tr>
<tr>
<td>12</td>
<td>55%</td>
<td>&lt;5%</td>
</tr>
</tbody>
</table>
What if we don’t have an OEL?

- Top of the band?
- Bottom?
- Middle?
COSHH Control Banding System

Table 6. Correlation between exposure band and hazard band

<table>
<thead>
<tr>
<th>Exposure band—solid (mg/m³)</th>
<th>Exposure band—liquid ppm</th>
<th>Hazard band</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10</td>
<td>&gt; 500</td>
<td>Not Recommended</td>
</tr>
<tr>
<td>1–10</td>
<td>50–500</td>
<td>A</td>
</tr>
<tr>
<td>0.1–1</td>
<td>5–50</td>
<td>B</td>
</tr>
<tr>
<td>0.01–0.1</td>
<td>0.5–5</td>
<td>C</td>
</tr>
<tr>
<td>0.001–0.01</td>
<td>0.05–0.5</td>
<td>D</td>
</tr>
<tr>
<td>&lt; 0.001</td>
<td>&lt;0.05</td>
<td>E</td>
</tr>
</tbody>
</table>

Periodic Testing

• Frequency depends on . . .
  – Hazards of contaminants
  – Potential for degradation or changes to the system
  – Presence of alarms or alert devices

• Could be weekly, monthly, quarterly, annual....
Groups 1 and 3

- 2 operations to evaluate:
  - Using toluene for cleaning parts
  - Using Stoddard solvent and trimethylbenzene for staining

Groups 2 and 4

- 2 operations to evaluate:
  - Using Skysol (naphtha) for cleaning parts
  - Using Stoddard solvent and trimethylbenzene for staining
Exercise

• Can take 8 full shift air samples – choose how many to collect for each chemical
• Stoddard solvent and trimethylbenzene can be collected simultaneously, but that counts as 2 samples
• Come up with a sampling strategy and write down your logic
• I will give you sampling results once you’ve decided on your strategy
• Note: You can choose to do this in two phases (i.e. take 4 samples, look at the results, then allocate the rest of the samples)
CONCLUSIONS
Accuracy and Precision of Experts: Importance of Context

• Expert judgment and therefore expert systems, such as control bands, are not good at precise estimates.

• However, they are good within an order of magnitude – and depending on the context, that is often sufficient.
Source: Hawkins and Evans, Appl. Ind. Hyg. 4: 61-68, 1989

\[ = 4.6 \ (2.2, \ 7.1) \]
True distribution of 90th percentile = 13.7 (10.2, 17.1)

Control Banding Assessment

- Data from similar processes with similar chemicals can be used to generate a realistic information about control capabilities
- Verification data should show that acceptance criteria are met ...
- But acceptance criteria depend on context – criticality, personal preference, feasibility, size of the data set
Control Banding Implications

- Bands should be at least one order of magnitude wide
- Exposure should be “acceptable” at the top end of the band
- Controls should be designed to achieve the bottom end of the band
Value of HHBs

- Containment achieved based on engineering controls, rather than personal protective equipment
- PPE for existing processes and for non-routine tasks, such as maintenance and cleaning
- Risk of occupational exposure minimized
- Facilities or processes not over-designed
- Allows management to select manufacturing facility capable of meeting the OEL
OEB value to NIOSH and AIHA

- Efficiency of authoritative OEL development is outpaced by the speed of new chemical introduction into commerce
  - Limited human and financial resources; may be limited data
  - Intensive process to assure accurate interpretation of data
- Can be used with minimal data
- Supports the definition of OEL-ranges for families of materials
  - By analogy (structure activity relationships and functionality)
- Provides a screening tool for the development of OELs
- Highlights areas where data are missing
OEB Value to Industrial Hygienists

- Provides guidance for materials without OELs
- Identifies hazards that should be evaluated for elimination or substitution
- Aligned with GHS for hazard communication
- Logical approach for initiating ERAM
- Facilitates the application of PtD to eliminate hazards and minimize risks to chemical agents
Resources and Web links

Control Banding and Tool Kits
NIOSH Topic Page
http://www.cdc.gov/niosh/topics/ctrlbanding/

ILO SafeWork

UK HSE COSHH Essentials
http://www.coshh-essentials.org.uk/

REACH

GHS
http://www.unece.org/trans/danger/publi/ghs/ghs_rev01/01files_e.html
http://www.osha.gov/dsg/hazcom/index.html