LONDON 2015
IOHA 10th IOHA International Scientific Conference

Occupational Exposure Assessment Tools, Models, and Data Sources Used for Risk Assessment and Risk Management of Chemicals

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10th IOHA International Scientific Conference
London, United Kingdom
April 28, 2015

Outline of Presentation

- Occupational Exposure (OE) and industrial Hygiene (IH) support to the Office of Pollution Prevention and Toxics (OPPT) Program Areas
- General Approach for OE (tiered approach, OE expression, and OE estimation hierarchy)
- Selected Tools, Models and Data Sources for OE
- Other OE Related Databases and Documents
- Current OE / IH Projects
- OE Information and Possible Projects of Interest
- Other Federal Agencies with OE Responsibilities

Note: The views in this presentation are those of the author and presenter and do not represent Agency policy or endorsement.

OE / IH Assessment Support to OPPT Program Areas

- As part of the risk assessment of chemicals under the Toxic Substances Control Act (or TSCA), OPPT assesses ecological and human health risks including risks to workers, consumers, and the general population.
- OE Support to Risk Assessments of New Chemicals
  - Initial OE assessments (e.g. screening-level)
  - Follow-up (including detailed) assessments
- OE Support to Risk Assessments of Existing Chemicals
  - Various types of assessments including screening-level to more detailed or advanced assessments
- OE / IH Support to Risk Management of Chemicals
  - Evaluation of adequacy and efficiency of engineering controls
  - Selection of PPE
  - Glove permeation and respirator cartridge testing
  - Exposure monitoring
  - Comparative evaluation of alternative formulations, chemicals or technologies

Tiered Approach to Occupational Exposure Assessment

- Initial or Screening-Level Assessment
  - Screening chemicals for further assessment
  - Conservative (protective)
  - Uses readily available data and information
- Detailed or Advanced Exposure Assessment
  - Focuses on selected exposure scenarios (e.g. those with higher and/or more widespread exposures)
  - More accurate, precise exposure assessment
  - Data quality standards are critical

Occupational Exposure Expression

- Routes
  - Inhalation
  - Dermal

- Duration (hours or days) & Frequency (days/year)

- Populations: workers in industrial settings (e.g. manufacturing plants) and commercial settings (e.g. automotive refinishing shop workers)

- Amounts
  - Concentrations -- parts per million (ppm) or mg/m^3
  - Potential or applied dose rate (mass based) – mg/day or mg/kg/day

Occupational Exposure Estimation: Hierarchy of Data and Methods Selection

1. Monitoring data for the chemical (personal and area)

2. Monitoring data for a “surrogate chemical” (similar physical/chemical properties and handling)

3. Mass balance or Generic scenario based on available information for specific industrial / commercial process or operation

4. Models

    a. Regulatory limits (release and worker exposure e.g., OSHA PELs for surrogate chemical or chemical present in same workplace as chemical)

    b. Mathematical models

5. Professional judgment

Selected Tools and Data Sources for OE Assessment

- Workplace scenarios
  - Industry Specific Generic Scenarios (GSs)
  - Emission Scenario Documents (ESDs)

- Chemical Screening Tool for Exposures and Environmental Releases (ChemSTEER)

- Other databases and technical documents

Generic Scenario and ESD

- What's in a generic scenario or ESD?
  - Process description
  - Mass balance data for process / operation
  - Monitoring data
  - Release and / or exposure models
  - Default values
  - Estimation equations and example calculations

- How are generic scenarios or ESDs developed?
  - Literature research
  - Industry input
  - New chemical case information and data
  - OECD (international) input and review

ESDs and GSs

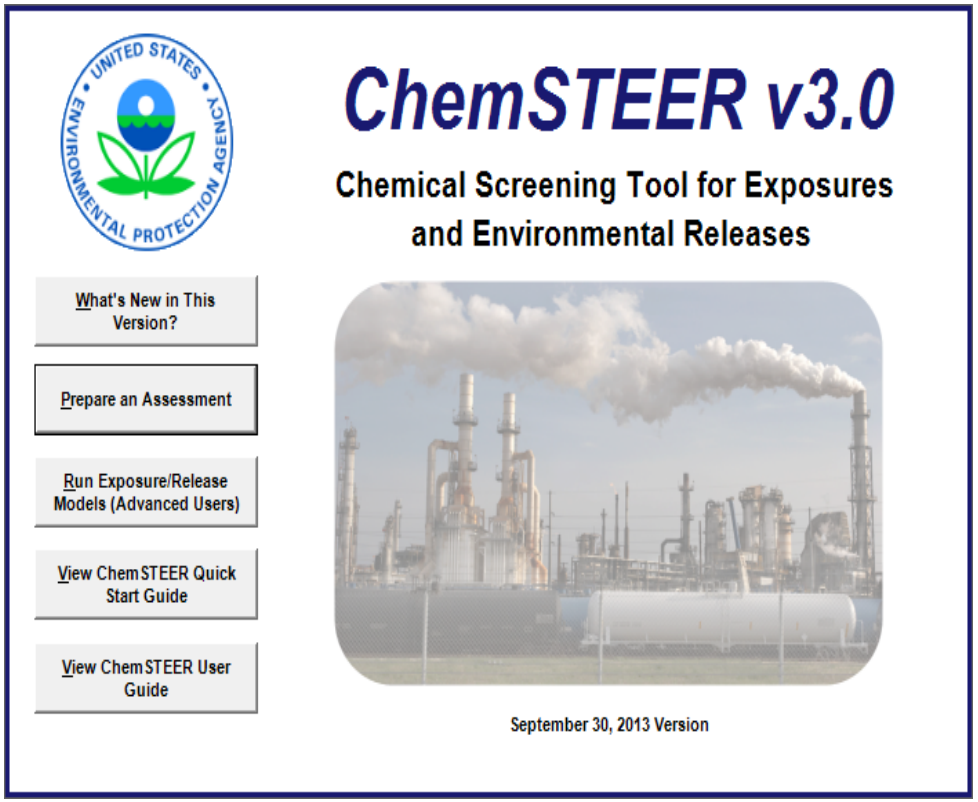
Published ESDs

- Use of Metalworking Fluids
- Blending of Fragrance Oils into Commercial and Consumer Products
- Formulation of Adhesives and Use of Adhesives
- Formulation of Radiation Curable Coatings, Inks and Adhesives
- Application of Radiation Curable Coatings, Inks and Adhesives
- Use of Photoresist in Semiconductor Manufacture
- Chemicals Used in Industrial and Institutional Laundries
- Spray Application of Coatings in Auto Refinishing
- Formulation and Application of Thermal and Carbonless Copy Paper Coatings
- Chemical Vapor Deposition in Semiconductor Manufacture
- Use of Textile Dyes

In-progress ESDs and GSs

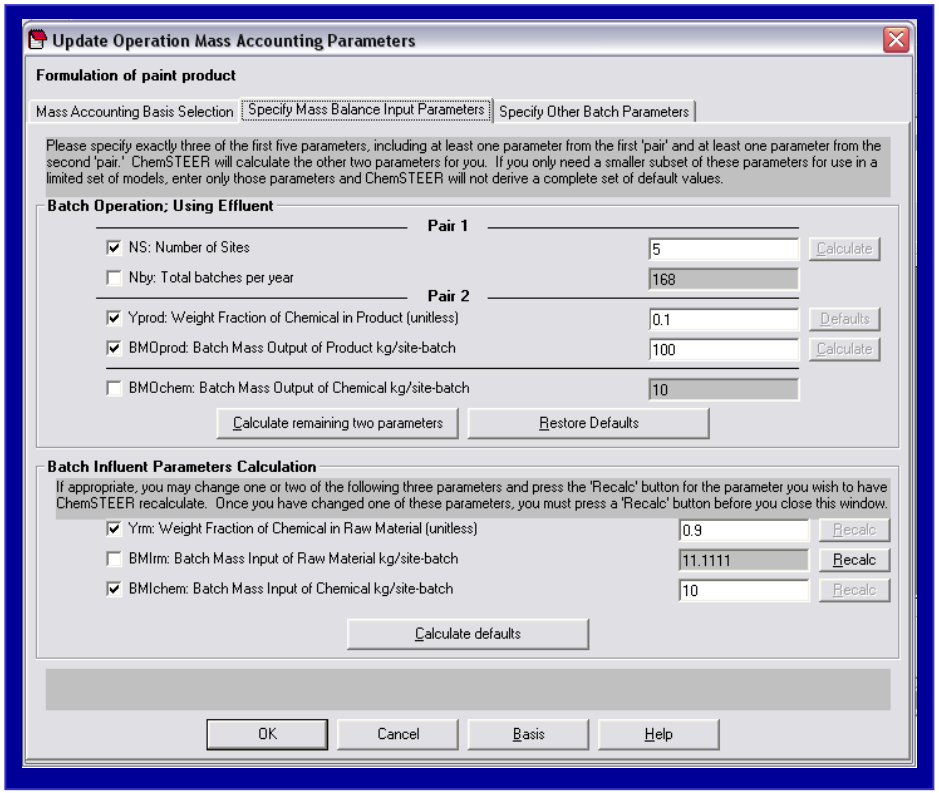
- Lube Oil Additives
- Aqueous Firefighting Foam
- Vapor Degreasing
- Fracking

What does ChemSTEER do and what is it used for?



- The PC-based application is a suite of methods and models used to produce screening-level estimates of workplace exposures and environmental releases.
- Its primary purpose is to support EPA's New Chemicals Program.
- Approximately 1,000 new chemicals assessments are prepared every year.
- The application can also be used to address data gaps when preparing more in-depth assessments.

Features – User-Friendly Design



- ChemSTEER is designed such that ***new, as well as experienced*** users can use the software to perform screening-level estimates
- ChemSTEER steps you through the process of creating an assessment scenario
- Every screen contains instructions of what inputs you must enter to proceed
- All default models are designed to be transparent (i.e., all assumptions and values are documented)

ChemSTEER contains an ***extensive Help System*** that documents the bases for every model and every default value. The Help System also contains a library of background documentation.

Types of Models in ChemSTEER

- Worker inhalation exposure:
  - ✓ vapor
    - ✓ presumptive PEL-limited
    - ✓ simple box model w/ vapor generation model
  - ✓ particulate/mist
    - ✓ presumptive PEL-limited
    - ✓ exposure factor (data) for small volumes
    - ✓ data for limited, use-specific activities
- Worker dermal exposure:
  - ✓ film on skin

Examples of ChemSTEER Worker Exposure Models

- 1. EPA/OPPT Small Volume Solids Handling Inhalation Model
- 2. EPA/OPPT Mass Balance Inhalation Model
- 3. Penetration Model for Estimating Generation Rates (indoor)
- 4. Mass Transfer Model for Estimating Generation Rates (outdoor)
- 5. OSHA PEL (Permissible Exposure Limit)-Limiting Model for Substance-Specific Particulates
- 6. OSHA PEL Limiting Model for Substance-Specific Vapors
- 7. OSHA Total PNOR (Particulate Not Otherwise Regulated) PEL-Limiting Model
- 8. OSHA Respirable PNOR PEL-Limiting Model
- 9. EPA/OPPT 1-Hand Dermal Contact with Liquid Model
- 10. EPA/OPPT 2-Hand Dermal Contact with Liquid Model
- 11. EPA/OPPT 2-Hand Dermal Immersion in Liquid Model
- 12. EPA/OPPT Direct 2-Hand Dermal Contact with Solids Model
- 13. EPA/OPPT 2-Hand Dermal Contact with Container Surfaces Model
- 14. 2 user-defined models, one inhalation and one dermal, that allow the user to create exposure estimates.

ChemSTEER Models: Example 1

- PEL-limited particulate/mist/vapor inhalation
  - ✓ assume compliance w/ OSHA for chemical concentrations (use of PEL normally results in high-end to bounding estimate)

PNOR: $Cm\ (mg/m^3) = KCk \times Ys$

Substance ratio: $Cm\ (mg/m^3) = KCk \times Ys / Ypel$

Vapor ratio: $Cv\ (ppm) =$

$[Cvk \times (VP \times Ys / MW) / (VPpel \times Ypel / MWpel)]$

or

$[1{,}000{,}000 \times X \times VP / 760]$, whichever is less

ChemSTEER Models: Example 2

- Mass balance (simple box) inhalation
  - ✓ converts vapor generation rate to exposure concentrations (derived from mass balance using ventilated “box”)

Cv (ppm) =

[(170,000 × T × G) / (MW × Q × k)]

or

[1,000,000 × X × VP / 760], whichever is less

ChemSTEER Models: Example 3

- Mass transfer coefficient vapor generation
  - ✓ estimates vapor generation rate for "Outdoor activities" (more appropriate for higher wind velocities)
  - ✓ results used with Mass Balance inhalation model

$$G\ (g/s) = \frac{1.93x10^{-7} \times MW^{0.78} \times X \times VP \times (1/29 + 1/MW)^{0.33} \times vz^{0.78} \times A}{(T^{0.4} \times d^{0.11} \times (T^{0.5} - 5.87)^{2/3})}$$

ChemSTEER Models: Example 4

- Penetration vapor generation
  - ✓ estimates vapor generation rate for “Indoor activities” (more appropriate for lower wind velocities)
  - ✓ results used with Mass Balance inhalation model

$$G\ (g/s) = \frac{8.24x10^{-8} \times MW^{0.835} \times X \times VP \times (1/29 + 1/MW)^{0.25} \times vz^{0.5} \times A}{(T^{0.05} \times d^{0.5} \times P^{0.5})}$$

ChemSTEER Models: Example 5

- AP-42 (displacement) vapor generation
  - ✓ estimates vapor generation rate for filling vessels with liquids (adapted from EPA AP-42)
  - ✓ results used with Mass Balance inhalation model

$$G\ (g/s) = f \times MW \times (3785.4 \times Vc) \times r \times X \times (VP / 760) / (3600 \times T \times R)$$

ChemSTEER Models: Example 6

- Dermal immersion/contact in liquid/solid
  - ✓ surface film density (mg/cm^2 exposure per event (from data) - related to activity (immersion or standard contact))
  - ✓ one event per day
  - ✓ Dexp (mg/day) = S × Qu × Yderm × FT

Other OE Related Databases and Documents

- Databases: EPA TRI, NEI and CDR; OSHA IMIS; OSHA CEHD; CDC NHANES
- Other International Risk Assessments
- IH Documents
  - (e.g. Decision Logic for OPPT Selection of Respirators for Chemical Substances, Guidance for Glove Permeation Testing)
- Compendium of Technical Documents / Policy Memos
  - (e.g. internal documents on drop categories, standard assumptions for efficiency of bag house/cyclone)
- Other Technical Guidance Documents
  - (e.g. Approaches for Estimating Occupational Exposure and Environmental Releases for Nanomaterials)
- Database of Exposure Related Information for CNT/CNF

OE Related Activities

- ESDs / Generic Scenarios
  - On-going effort to update / develop generic scenarios / ESDs
  - Scenarios under development include:
    - Lube Oil Additives
    - Aqueous Firefighting Foam
    - Vapor Degreasing
    - Fracking

- ChemSTEER
  - Add a new mass balance near field/far field model
  - Continue enhancing the user-friendliness aspect
  - Program additional ESDs into ChemsTEER

OE Related Activities (con't)

- Comparison of predictive models in ChemsTEER with those in other OECD models
  - This project will involve reviewing the underling theory and assumptions behind the various models

- Guidance for OE assessments of Nanomaterials
  - Update Interim Guidance on Approaches for Assessing and Controlling Workplace Releases and Exposures to Nanomaterials
  - Develop Inhalation Monitoring Guidance for Exposure to Nanomaterials

OE / IH Information and Possible Projects of Interest

- Occupational monitoring data in various industry sectors (both inhalation and dermal)
- Biomonitoring data
- Data on efficiency of engineering controls (e.g. LEV)
- Studies and data on thickness of film for dermal exposure estimation
- Comparison of dermal exposure models and default input parameters
- Survey to compile inventory of databases with occupational exposure data (both inhalation and dermal)
- Comparison of predictive generation and mass balance models in ChemsTEER with those in other OECD models
- Development of industry specific occupational exposure scenarios (OES). This could complement ESDs

OE-Related Tools and Topics: OSHA*

The Occupational Safety and Health Administration (OSHA) is tasked with setting and enforcing occupational safety and health standards by providing training, outreach, education and assistance. Examples include:

- Respiratory Protection

https://www.osha.gov/SLTC/respiratoryprotection/index.html

- Respiratory Protection E-Tool (for respirator cartridge testing)

https://www.osha.gov/SLTC/etools/respiratory/index.html

- Personal Protective Equipment

https://www.osha.gov/SLTC/personalprotectiveequipment/index.html

- Dermal Exposure

https://www.osha.gov/SLTC/personalprotectiveequipment/index.html

- Nanotechnology

https://www.osha.gov/dsg/nanotechnology/nanotechnology.html

- Permissible Exposure Limits

https://www.osha.gov/dsg/topics/pel

* Information compiled from OSHA's public website

OE-Related Tools and Topics: NIOSH*

NIOSH research works to improve workplace safety and health through safe practices, policies, and procedures. Some examples include:

- Engineering Controls
http://www.cdc.gov/niosh/topics/engcontrols/
- Respirators
http://www.cdc.gov/niosh/topics/respirators/
- Nanotechnology
http://www.cdc.gov/niosh/topics/nanotech/
- Recommended Exposure Limits
http://www.cdc.gov/niosh/topics/cancer/policy.html
- Exposure Assessment Research
http://www.cdc.gov/niosh/programs/expa/
- Skin Exposures and Effects
http://www.cdc.gov/niosh/topics/skin/
- National Occupational Research Agenda
http://www.cdc.gov/niosh/nora/

* Information compiled from NIOSH's public website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April 25th-30th 2015
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