EXPOSURE ASSESSMENT MODELING UTILIZING I H MOD 2.0 – FREE AND EASY TO USE

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EXPOSURE MODELING EXPERIENCE

> INDOOR AIR MODELING

AIHA-RECOMMENDED INDOOR MODELS

PARTICULATE MODELS

> OUTDOOR AIR MODELING

EPA-RECOMMENDED AERMOD

AIHA-RECOMMENDED SIMPLE PLUME MODELS

Overview

> IH MOD 2.0 Background Information

– What is modeling?

– Why perform modeling?

– Model selection

– Overview of models in IH MOD

– Monte Carlo simulation

What is IH MOD?
> IH MOD is an excel-based tool
> Simplifies the process of running many AIHA-recommended models
> Created by AIHA’s Exposure Assessment Strategies Committee
– Tom Armstrong
– Daniel Drolet
- Heather Avens
> Free and easy to use

What is a mathematical model?

> Simplified estimate of reality

> "An equation that can estimate the concentration of a contaminant in a work-space based on physical and chemical input parameters"

- Tom Armstrong

> "All models are wrong, but some are useful"

- E.G. Box, statistician

Modeling Resources

> Books

– "Mathematical Models for Estimating Occupational Exposure to Chemicals"

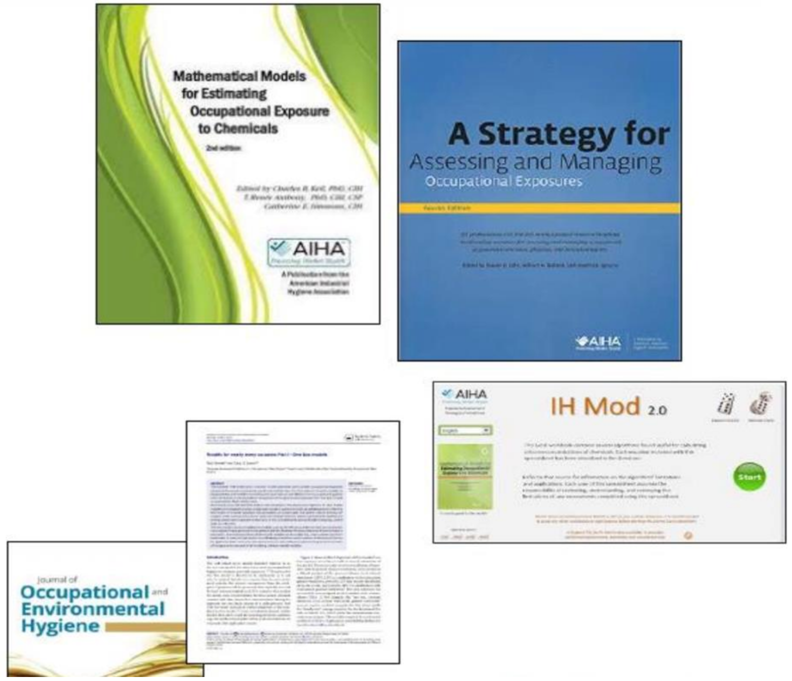
– "A strategy for Assessing and Managing Occupational Exposures"

> IH MOD 2.0

– IH MOD 2.0 Support File

> JOEH & Other Peer Reviewed Journals

> PDCs sponsored by the Exposure Strategies Assessment Committee



IH MOD and the AIHA Math Modeling Book

> IH MOD is an excel spreadsheet tool

– Supplement to the AIHA Math Modeling Book

– Includes many of the inhalation models in the AIHA Math Modeling Book

– Coded with equations to carry out the model calculations

> Available through the AIHA Exposure Assessment Strategies committee website

IH Mod 2.0

Deterministic | Monte Carlo

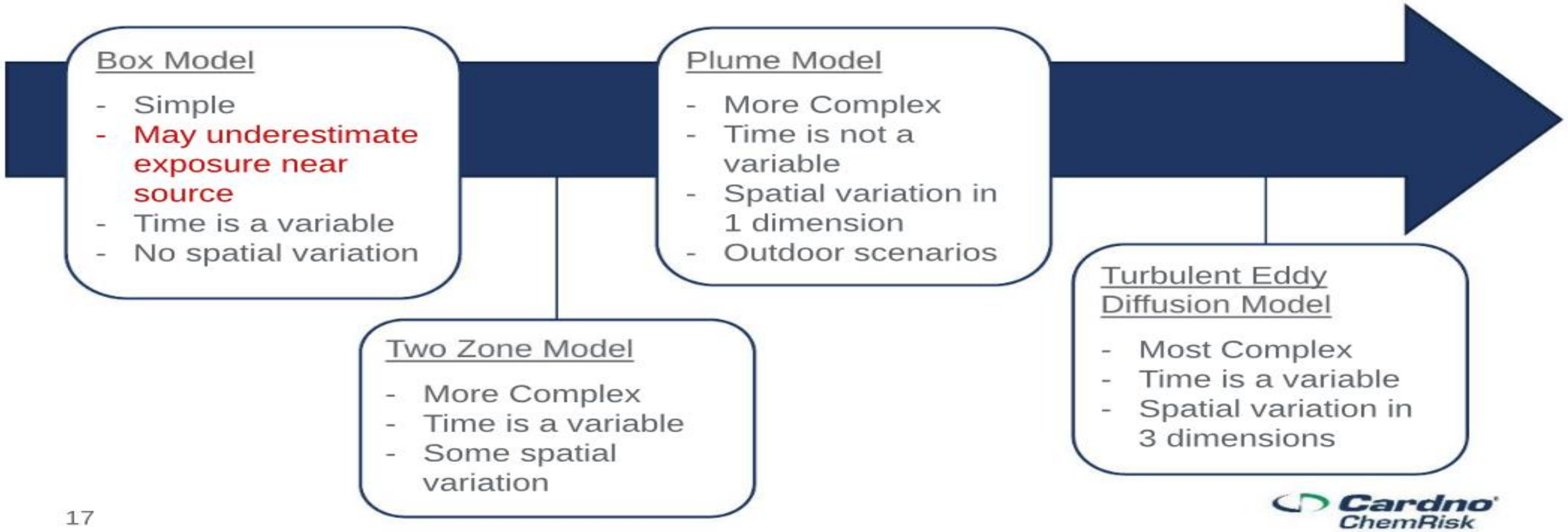
1	*Well Mixed Box Room Model*	Well-Mixed Box Models
2	*Well-Mixed Room Model with Backpressure*	Well-Mixed Box Models
3	*Well-Mixed Room Purging Equation*	Well-Mixed Box Models
4	*Spill Model, Decreasing Emission*	Well-Mixed Box Models
5	*Turbulent Eddy Diffusion without Advection following a Pulse Release*	Turbulent Eddy Diffusion Models
6	*Eddy Diffusion without Advection given a Constant Mass Emission Rate*	Turbulent Eddy Diffusion Models
7	*Eddy Diffusion with Advection following Pulse release*	Turbulent Eddy Diffusion Models
8a	*Two-Zone Model, Constant Emission*	Two-Zone Models
8b	*Two-Zone Model, Decreasing Emission*	Two-Zone Models
10	*Turbulent Eddy Diffusion with Advection and with a Constant Emission Rate*	Turbulent Eddy Diffusion Models
11	*Near and Mid - Field plume models*	Plume Models

This file has been created by Daniel Drolet and Tom Armstrong with review by Michael Jayjock

> A tiered approach is recommended

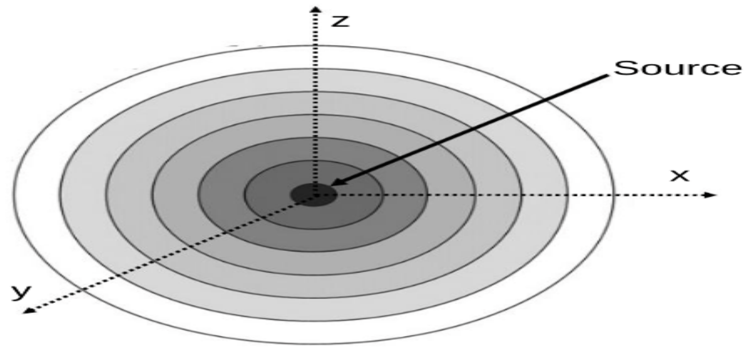
– If a simple model yields an estimated concentration exceeding the occupational exposure limit (OEL), then a more rigorous model can be employed

How Simple or Complex are the IH MOD 2.0 Models?



Turbulent Eddy Diffusion Model: Overview

- Continuous gradient of decreasing concentration moving away from a source
  - Thee-dimensional contour surfaces of equal concentration
- Based on macroscale random movement of parcels of air
  - Assumed no source momentum
- Does not account for dilution ventilation by room exhaust



Turbulent Eddy Diffusion Models in IH MOD 2.0

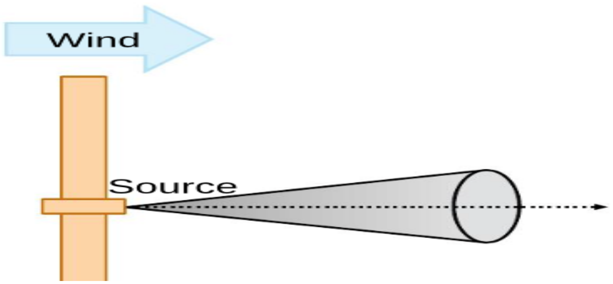
- Four model variants available (#5, 6, 7, and 10)

5	*Turbulent Eddy Diffusion without Advection following a Pulse Release*
6	*Eddy Diffusion without Advection given a Constant Mass Emission Rate*
7	*Eddy Diffusion with Advection following Pulse release*
10	*Turbulent Eddy Diffusion with Advection and with a Constant Emission Rate*

- Summary of options
  - Pulse release vs. constant emission
  - With vs. without advection

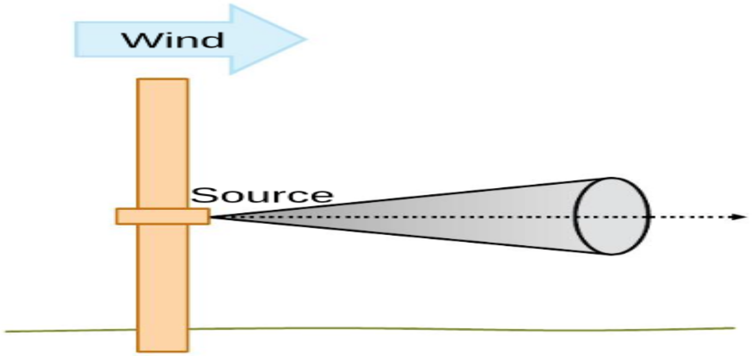
Plume Model: Overview

- Two simplified Gaussian plume models:
  - Near-field plume model
    - Up to 3 m from source
  - Far-field plume model
    - 3 to 100 m from source

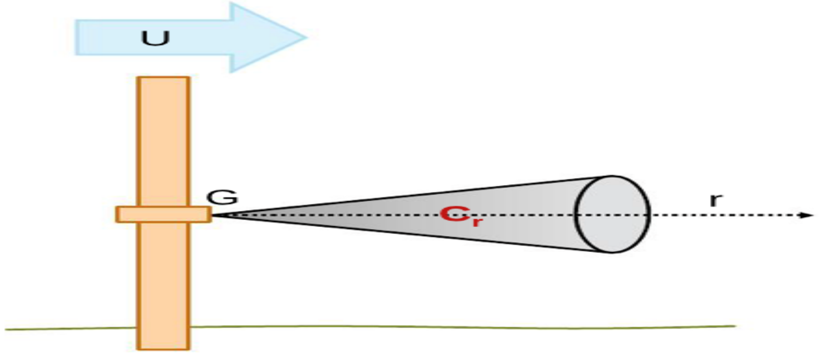


Plume Model: Overview (continued)

- Point source located outdoors
- Not for high pressure, direction jets
  - Good for slowly leaking process equipment
- Estimates centerline concentration, directly downwind
- Pasquill-Gifford atmospheric stability class C
  - Representative of typical atmospheric conditions



Plume Model: Schematic



	Parameter	Unit
G	Generation rate	mg/min
U	Wind Velocity	m/min
r	Location of worker breathing zone	m
C_r	**Concentration at worker location**	**mg/m³**

Plume Models in IH MOD 2.0

#11. Near and Mid-Field Plume Models

- A single spreadsheet includes both models
- Toggle button to get results for near vs. far-field plume model

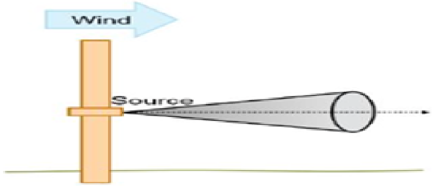
Case Study Example #3: Leaking Process Pump

- *This example is an adaptation of Examples 16.1 and 16.2 in the AIHA Math Modeling book*
  - *Modified to incorporate Monte Carlo Simulation*
- You are reviewing design plans that include a pump with a single mechanical seal
- The seal manufacturer provides literature indicating that this seal type has a loss rate of 1 to 10 mg/minute
- One component of the pumped mixture ("Component A") has a low occupational exposure limit (8-hr TWA of 0.01 mg/m³, no STEL)
- The design plans include an operator station about 5 m away from the pump
  - You want to evaluate the operator's potential exposure

Cardno ChemRisk

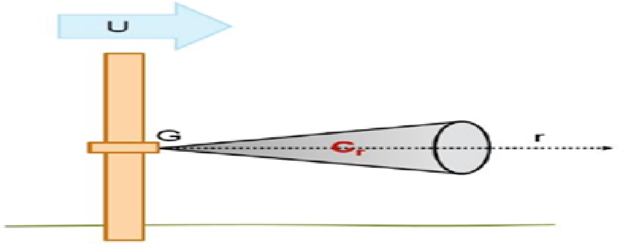
Model Selection

- The pump and the operator station are both located outdoors
- The operator is 5 m away from the pump
- You chose to use the mid-field plume model (IH MOD model #11)
  - Recommended for estimating concentrations 3 to 100 m from an outdoor source



Cardno ChemRisk

Mid-Field Plume Model – Inputs Needed



	Input Parameter	Unit
G	Generation rate	mg/min
U	Wind Velocity	m/min
r	Location of worker breathing zone	m

Mid-Field Plume Model – Input Values

Input Parameter	Value	Units	Rationale
Contaminant mass emission rate (G)	?	mg/min	
Wind Velocity (U)	?	m/s	
Distance from source (r)	5	m	Specified in design plan

Generation Rate

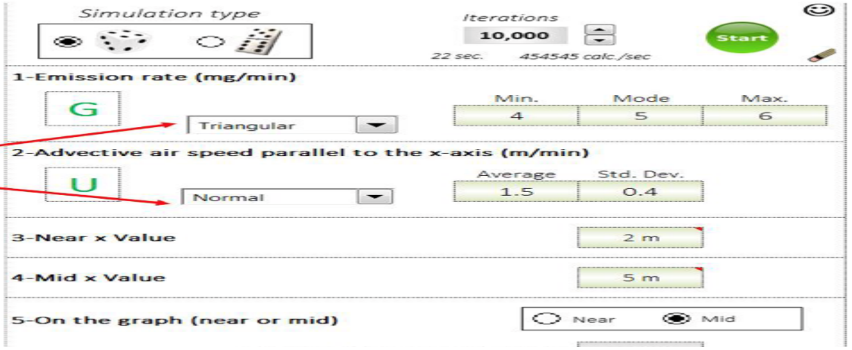
> This type of mechanical seal has a loss rate of 1 to 10 mg/minute
  – It is unknown whether the particular seal used will have a loss rate closer to 1 or 10 mg/min, therefore you assume that the loss rate will be 10 mg/min

> Based on discussions with the lead chemical engineer, the concentration of Component A in the pumped fluid is anticipated vary over the course of the daily batch process
  – Typically constitute about 50% of the mixture, but may range between 40 and 60%

> Since the percent of Component A varies over the course of the work day, you want to account for this variability
  – Wind speed is also variable throughout the work day
  – You decide to use a Monte Carlo Simulation

Mid-Field Plume Model with MC Simulation – Inputs Needed

Select a Distribution:
Normal
Uniform
Lognormal
Triangular



NEED TO USE MORE OFTEN IN PLACE OF AIR SAMPLING. REAL TIME INSTRUMENTS AND MODELING ARE FUTURE.

USING KNOWLEDGE, EXPERIENCE AND MODELING IS AS ACCURATE AS AIR SAMPLING DUE TO ALL THE VARIABLES INVOLVED.

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