

EXPOSURE ASSESSMENT TOOLS FROM THE AMERICAN INDUSTRIAL HYGIENE ASSOCIATION: A REVIEW WITH EXAMPLES OF THEIR USE

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INTRODUCTION

SOFTWARE TOOLS DEVELOPED IN THE AIHA EXPOSURE ASSESSMENT STRATEGIES COMMITTEE PROVIDE WAYS TO STATISTICALLY EVALUATE DATA AND EVALUATE OCCUPATIONAL/CONSUMER EXPOSURE SCENARIOS. THE TOOLS ARE FREE AND ARE REGULARLY UPDATED. SEVERAL (1 TO 3 BELOW) ARE AVAILABLE IN MULTIPLE LANGUAGES. FIVE OF THE MAIN TOOLS WILL BE DISCUSSED WITH EXAMPLES OF THEIR USE.

OUTLINE OF THE TOOLS TO DISCUSS

- IH EXPOSURE SCENARIO TOOL

- GUIDES EVALUATION OF THE WORKPLACE, SPECIFIC TYPE OF ENGINEERING CONTROLS.

- QUALITATIVE EXPOSURE ASSESSMENT CHECKLIST

- REQUIRES: AN OEL; THE VAPOR PRESSURE OF THE WORKPLACE CONTROLS AND THE REQUIRED LEVELS OF READILY AVAILABLE INFORMATION AND HAS BEEN MADE BY JUDGMENTS. I

- IH STAT

- AN EXCEL APPLICATION THAT CALCULATES A VARIETY OF EXPOSURE STATISTICS, PERFORMS GOODNESS OF FIT TESTS, AND GRAPHS EXPOSURE DATA.

- IH MOD

- A MATHEMATICAL MODELING EXCEL SPREADSHEET SUITE OF 11 ALGORITHMS USED FOR ESTIMATING AIR CONCENTRATION EXPOSURES. A NEW VERSION IH MOD 2.0 ADDITIONALLY PROVIDES NATIVE IN MS EXCEL MONTE CARLO SIMULATION.

- IH SKINPERM

- AN EXCEL APPLICATION FOR ESTIMATING THE DERMAL UPTAKE OR EVAPORATION OF DERMALLY DEPOSITED AGENTS. FOUR DERMAL ABSORPTION SCENARIOS CAN BE SIMULATED INCLUDING ESTIMATES OF DERMAL UPTAKE FROM AIR.

Given the five tools and limited time expect just quick overviews of functionality. If you are interested, further details on any of these tools are available with the tools themselves.

SCENARIO EVALUATED. USE OF 1-BROMOPROPANE IN A DRY CLEANING OPERATION

- DESCRIBED BY BLANDO 2010 (J. AIR & WASTE MANAGE. ASSOC. 60:1049–1056)
- SPECIFIC TASKS
 - ADDITION OF 5 GALLONS OF 1 BP THROUGH THE FRONT DOOR OF THE DRY CLEANING SHOP
 - REMOVAL OF CLOTHES AT END OF DRY CLEANING CYCLE AND EXPOSURE TO RESIDUAL 1-BP FROM THE WASHER
- SHOP VOLUME 280 CUBIC METERS TOTALS
- VENTILATION RATE NOT SPECIFIED IN BLANDO REPORT
 - ASSUME ACH FROM US EPA EPA DOCUMENT# 740-R1-5001 FEBRUARY 2016
 - OTHER DETERMINANTS DERIVED FROM SAME EPA DOCUMENT
- EVALUATE NEAR FIELD OPERATOR EXPOSURES
- EVALUATE DERMAL EXPOSURE VIA 1-BP CONTACT WITH HANDS AND ALSO WHOLE BODY DERMAL VAPOR UPTAKE FROM A NEAR FIELD AIR CONCENTRATION

IHEST OPENING SCREEN

This tool helps structure and document the basic characterization of an exposure scenario.

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IHEST
Exposure Scenario Tool

This tool was designed to facilitate the capture and organization of basic characterization information and data. Systematic collection of exposure determinant data is useful in developing more accurate exposure profiles, and may help improve exposure judgment accuracy. Further, accurate documentation of these determinants along with any personal exposure data provide context around those data, supporting better decision making and more robust risk management recommendations.

Using the tabs provided, please fill out those sections or cells for which you have information or data.

Instructions for filling out scenario forms

- Step 1 : Scenario info
- Step 2 : Basic Characterisation
- Step 3 : Exposure determinants
- Step 4 : Exposure monitoring data
 - Inhalation
 - Dermal
 - Noise

Version 15 This file has been created by Susan F. Arnold, Jennifer Sahmel and Daniel Drolet

IHEST BASIC CHARACTERIZATION

IHEST
Exposure Scenario Tool

2- BASIC CHARACTERIZATION

Scenario Description

If necessary, increase row size by dragging the "divider line" underneath the row

Process overview: Generation 3 dry to dry dry cleaning machine use

Task description: Task 1. Operator adding 5 gallons of "make up" solvent to the machine for 1 to 2 minutes once per day. Task 2. Removal of cloths from machine at the end of the cycle approximately 5 minutes and 14 times per day

Description of exposure controls: The generation 3 machine is closed cycle, and solvent is recovered prior to the end of the cleaning cycle. The shop has general ventilation only

Number of individuals in SEG?: 1

Description of SEG: Machine operator who maintains the machine solvent and loads and unloads clothing multiple times during the day

Worker time activity budget - decide if same for inhalation, dermal, noise Same info for inhalation and dermal

	Min	Max	
duration close to source	210	210	Inhalation
duration away from source but still in work area	270	270	
duration out of work area	0	0	
duration close to source	210	210	Dermal
duration away from source but still in work area	270	270	
duration out of work area	0	0	

Source description: Solvent vapor displaced during solvent addition and residual solvent vapor from machine d

Chemical Agent Data

description of chemical makeup (individual contaminant or mixture): 1-bromopropane

chemical composition:

contaminant form: liquid

properties of contaminant (for skin contact):

temperature at which contaminant is handled/added to process: -C estimated measured

vapor pressure at temperature handled: 143 -- estimated measured

(values between 10^{-4} - 10^4 mm)

octanol/water partition coefficient: 2.1 estimated measured

(values between 10^1 - 10^5)

octanol/air partition coefficient: estimated measured

(values between 10^1 - 10^6)

molecular weight compound: 123 estimated measured

molecular weight chemical of interest: 123 estimated measured

octanol/air partition coefficient of vehicle or mixture if chemical of interest is small component of overall mixture: NA estimated measured

Method or approaches?:

After a little experience, this tool is quick and efficient and the information is very useful for designing a survey or other estimation technique such as mathematical modeling

IHEST EXPOSURE DETERMINANT DATA

IHEST

Exposure Scenario Tool

3- EXPOSURE DETERMINANT DATA

average? Minimum Maximum Minimum

Ventilation rate 4.6 88 m³/min Local air velocity (at 1 meter from source) Minimum

Physical Layout Data


Room layout description (e.g. spacious, occluded areas or confined areas?)
 280 cubic meter dry cleaning shop. Task 1 Generation rate for solvent addition based on saturation concentration and 5 gal displaced volume from machine. Task 2 generation rate based on US EPA Generation 3 residual concentration in dry cleaning machine drum. 5 gallons equals 19,000 ml equals 968326 mg/M3. From EPA EPA Document#740-R1-5001 February 2016, residual solvent concentration in the drum ranges from 2000 to 8600 ppm (10000 mg/M3)

Generation rate 18393 mg/min Chemical usage rate (as applicable) 24

Number of Sources: 1

Room dimensions Width Length Height Surface 0.0 m²

DERMAL

Exposed body surface areas  None Head Legs Fingertips ForeArms
 Total body Trunk (includes neck) Palm and fingers Arms
 Hands

Duration/Intensity of dermal contact splash

Frequency of dermal contact intermittent

Dermal retention time Unlikely (volatile, very dry, large particulate)

Concentration of chemical of interest in mixture high (50-100%)

These may all be key factors in a qualitative judgement guided assessment or in designing a survey or may be used to guide model and input parameter selection

QUALITATIVE

This tool employs decision heuristics that have been found useful and that improve the general accuracy of qualitative decisions on exposure



Qualitative Exposure Assessment tool

The Checklist

This qualitative exposure assessment tool includes 3 checklists:

Checklist #1 and #2 are for assessing purely or relatively purely volatile and semi-volatile agents.



Use Checklist #3 to assess particulates, fibers and aerosols.



BEFORE USING:

Read and be sure you understand the steps as outlined on the **Guide tab**.
Calibrate the tool before making exposure judgments



This tool is useful for assessing exposures involving agents that are purely or relatively purely volatile and semi-volatile, or fiber, aerosol or particulate. It requires only a few inputs and facilitates a semi-quantitative assessment.
In more complex scenarios such as those involving mixtures, polymers, decomposition products, an added step is required that determines an adjusted vapor pressure or emission rate.



Disclaimer

Version 33

Conception: Susan F. Arnold, Mark Stenzel and Daniel Drolet

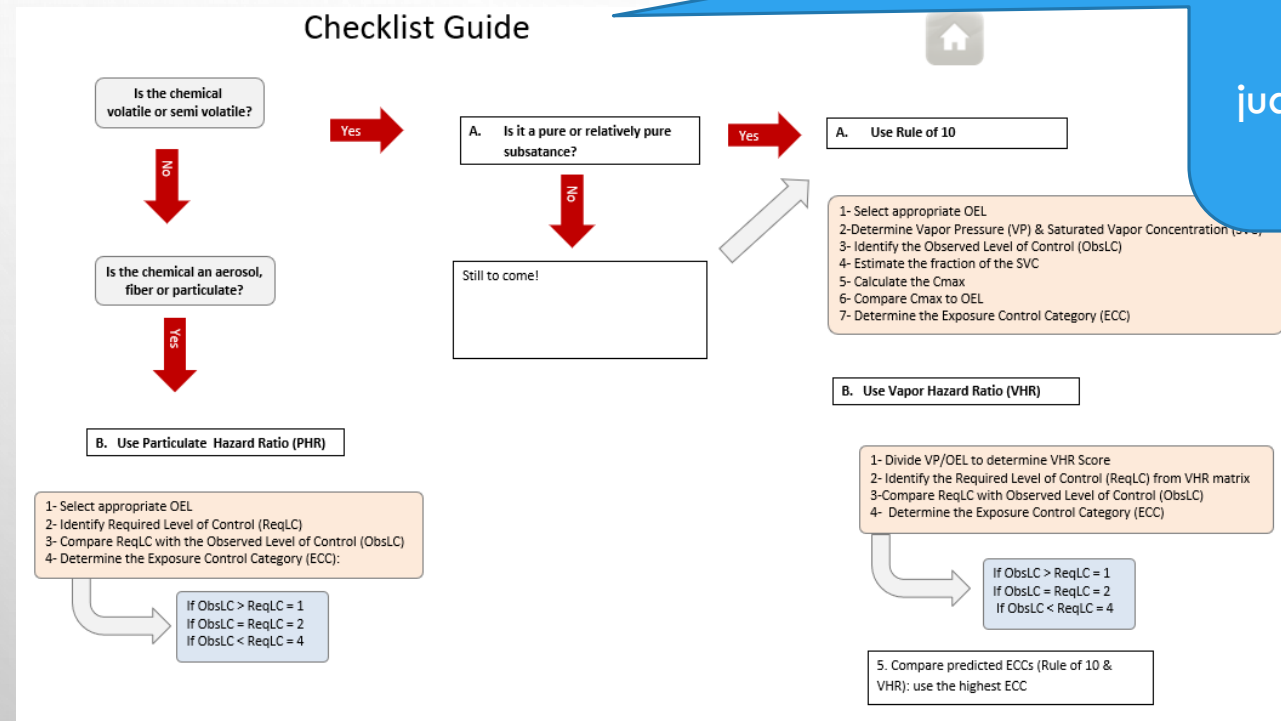


The user can assess volatile or semi-volatile agents or particulates, fibers or aerosols

It is always important to understand a tool before using it!

QUALITATIVE EXPOSURE ASSESSMENT TOOL CHECKLIST GUIDE

This guide outlines the model's content and branching logic of judgement and decision heuristics



Vapor pressure is a key determinant

QUALITATIVE EXPOSURE ASSESSMENT TOOL

GASES

A key piece is the expected or observed level of control

- 0** 95th %ile < 1% OEL
- 1** 95th %ile > 1 < 10 % OEL
- 2** 95th %ile > 10% < 50% OEL
- 3** 95th %ile > 50% < 100% OEL
- 4** 95th %ile > 100% OEL

The database covers a number of compounds, but a specific one can be entered here

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Worker Health
Assessment
Tool
Committee

Qualitative Exposure Assessment tool
Gas and Vapor

Temp. 25°C

Reference value
 OSHA PEL ACGIH TLV

Vapor pressure
 Sat Vap Antoine

C.A.S. Select a substance (s) OEL MPP

1	2	3	OEL	MPP
Allyl alcohol				

Name
1-Bromopropane

Select ObsLC Good - General

Factor 1/1,000th of Saturation

YHR
YHR scale

Results

SYC	192000 ppm
C _{max}	192 ppm
X _{max}	192000 %
Category	4


Recommended Control :
+ respirators & engineering controls, work practice controls

Select the Obs
General Ventilation * 3 to 6 air turnover per hr

picture Predicted exposure Category **4**

The result is as an AIHA Exposure Category

QUALITATIVE EXPOSURE ASSESSMENT TOOL PARTICULATES, FIBERS AND AEROSOLS

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Strategies Committee

Qualitative Exposure Assessment tool
Particulates, Fibers and Aerosols

Select OEL concentration range in mg/m³ ≤ 0.01 to 0.001

? **PHR Scale** 5

ReqLC Containment

Select the ObsLC Good – General + fans ~ 6 to 8 air turnovers/hr.

Predicted exposure category 4

Version 33

Conception : Susan F. Arnold, Mark Stenzel and Daniel Drolet

These tools must not be used without a good understanding of the strengths and limitations of the heuristics and of the terminology

IH STAT – THE OPENING SCREEN



Multilingual IHSTAT+

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This file was originally created by John Mulhausen and then modified in its multilingual version by Daniel Drolet et al.

If this file doesn't work....

Enable macros when opening this file.

Activer les macros à l'ouverture du fichier.

Attivare le macro all'apertura del file

Ativar macros quando abrir este arquivo.

इस फ़ाइल खोलने जब स्थूल सक्षम है.

이 파일을 열 때 매크로를 활성화함.

Aktiver makroer når du åpner denne filen

ファイルを開く時マクロを有効にしてください

Habilite los macros cuando abra este archivo.

Beim Öffnen der Datei Makros aktivieren.

注意: 打开该文档时请启用宏。

Při otevření tohoto souboru povolte makra.

Macro's inschakelen bij het openen van dit bestand

Dosyayı açarken makroları etkinleştirin

Запустите работу макросов при открывании документа

This file requires that macro security level of Microsoft Excel must be set in order to enable MACROS.

For more information, refer to the Microsoft Web site:

2000 / 2003 2007 2010 2013

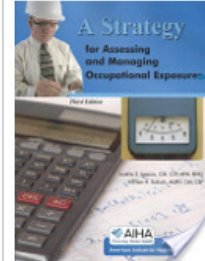


Languages

- English
- Français
- Italiano
- Portuguese
- Hindi
- Korean
- Turkish
- Japanese
- Español
- Deutsch
- Chinese
- Český
- Dutch
- Norwegian
- Russian

Now with 15 choices of language

The program uses MACROS which must be enabled



A full discussion on how to analyze and interpret exposure data can be found in...

Ignacio, J. and, Bullock, B. (editors) *A Strategy for Assessing and Managing Occupational Exposures, 3rd Edition.* Fairfax, VA: AIHA Press, 2006

This book gives more information on the statistical techniques and more.

IHSTAT+ : v. 235, Dec 2013

IH STAT ANALYSIS — DATA FROM BLANDO 2010 SH R TWA

Industrial Hygiene Statistics

OEL
0.1

Sample data

54
42
13
13

Descriptive statistics

Number of samples (n)	4
Maximum (max)	54
Minimum (min)	13
Range	41
Mean	32
Median	30.5
Standard deviation (s)	19.3
Geometric mean	27.4
Geometric standard deviation	1.95
Percent above OEL	100.0%

Test for distribution fit

W-test of log-transformed data
Lognormal (α = 0.05) ? Yes

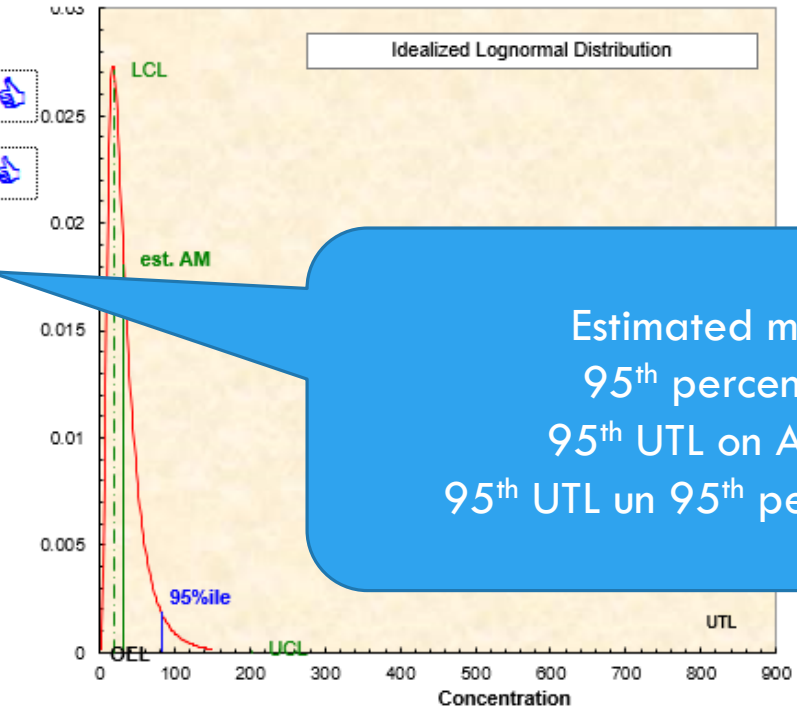
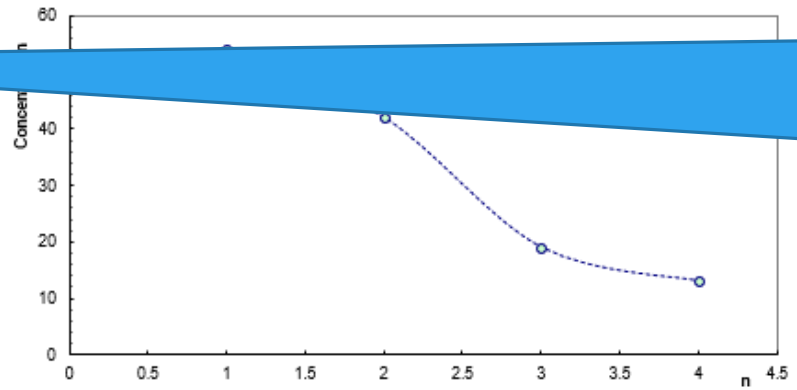
W-test of data
Normal (α = 0.05) ? Yes

Lognormal parametric statistics

Estimated Arithmetic Mean - AM est.	32.100
LCL1,95% - Land's "Exact"	19.000
UCL1,95% - Land's "Exact"	201.000
95th Percentile	81.892
UTL95%,95%	844
Percent above OEL	100.0%
LCL1,95% %>OEL	
UCL1,95% %>OEL	

Normal parametric statistics

Mean	32
LCL1,95% - t statistics	9.325
UCL1,95% - t statistics	54.675
95th Percentile - Z	63.693
UTL95%,95%	131
Percent above OEL	95.1%



The user sets the OEL and enters the data (up to n=200)

Various parameters are calculated and shown graphically

Estimated mean 32 ppm (161 mg/M3)
 95th percentile 82 ppm (412 mg/M3)
 95th UTL on AM 201 ppm (1011 mg/M3)
 95th UTL un 95th percentile 844 ppm (4245 mg/M3)

IH MOD 2.0 MATHEMATICAL MODELS TO ESTIMATE AIR CONCENTRATIONS

- IH MOD 2.0 INCLUDES MONTE CARLO SIMULATION TO EVALUATE PARAMETER UNCERTAINTY AND VARIABILITY IN THE DETERMINISTIC MODELS GIVEN IN IH MOD 1.0, STILL ***ALL IN EXCEL***, WITH NO OTHER SOFTWARE NEEDED!
 - THE CALCULATIONS ARE SET TO GIVE THE 5TH, 25TH, MEDIAN, 75TH AND 95TH PERCENTILES OF THE RESULTS DISTRIBUTION AND THIS IS NOT USER CONFIGURABLE.
 - MCS CALCULATIONS CAN BE VERY USEFUL WHERE YOU HAVE A POSSIBLE RANGE OF VALUES FOR CERTAIN MODEL PARAMETERS, SUCH AS A MINIMUM AND MAXIMUM FOR THE VENTILATION RATE, OR A MINIMUM, MOST PROBABLE AND MAXIMUM FOR THE CONTAMINANT GENERATION RATE, OR A LOG-NORMAL DISTRIBUTION OF AIR VELOCITY.
- THE CONCENTRATION VS TIME (OR TWA VS TIME) CURVES AT THE GIVEN PERCENTILES CAN PROVIDE NEW INSIGHTS INTO TIME AND VARIABILITY PATTERNS

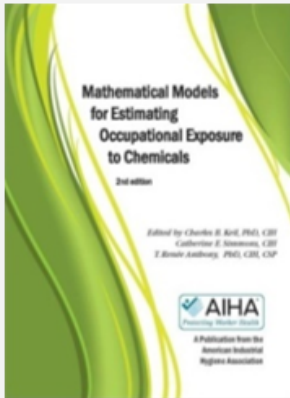
This is What You First See



Protecting Worker Health

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Strategies Committee

English



Optimize Zoom

720p 1080p 1440p 2000p

It will be available in multiple languages, given volunteers to complete translations!

This Excel spreadsheet contains several algorithms found useful for calculating airborne concentrations of chemicals. Each equation included with this spreadsheet has been described in the literature.

Refer to that source for information on the algorithms' limitations and applications. Each user assumes the responsibility of reviewing, understanding, and using any assessments completed using this spreadsheet.

Choose a screen resolution that suits your computer (but you can zoom too)

Monte Carlo simulation process NEEDS a LOT of your system resources. Please close any other workbooks or applications before starting the Monte Carlo simulation process.

Mod 2.0



Determinist



Monte Carlo

Click Here to Start



IH Mod 2.0 uses a lot of system resources, but we have run it in Windows 7, Excel 2010 on a 10 year old netbook with an Atom processor and just 2 GB of ram.



THE TWO-ZONE MODEL WITH A CONSTANT EMISSION RATE MCS

Choose the distribution type and set the parameters.

The normal distribution is truncated to avoid zero and negative values

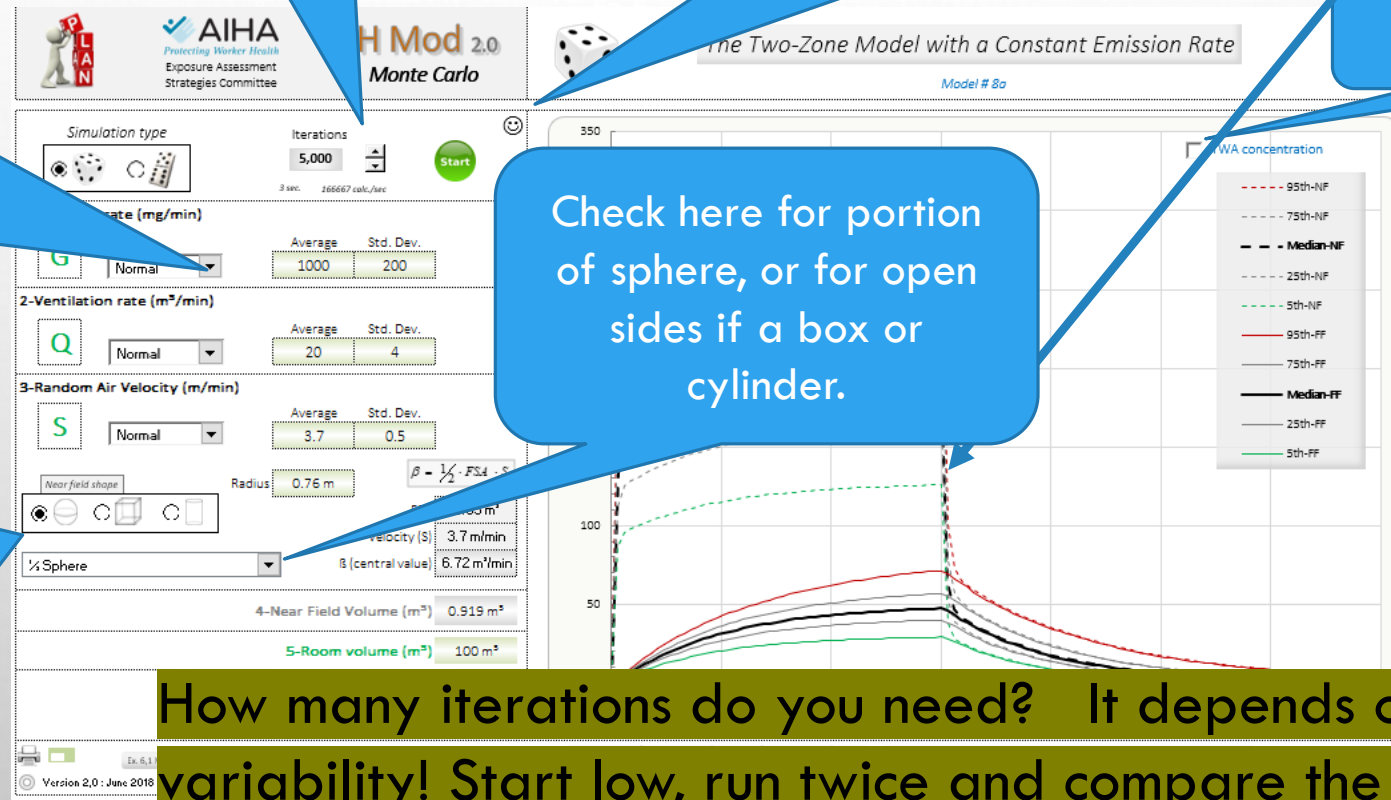
Set the number of iterations.

Smile = good to go!
Frown = parameters, etc. not quite right!

Show graph for TWA or C vs T

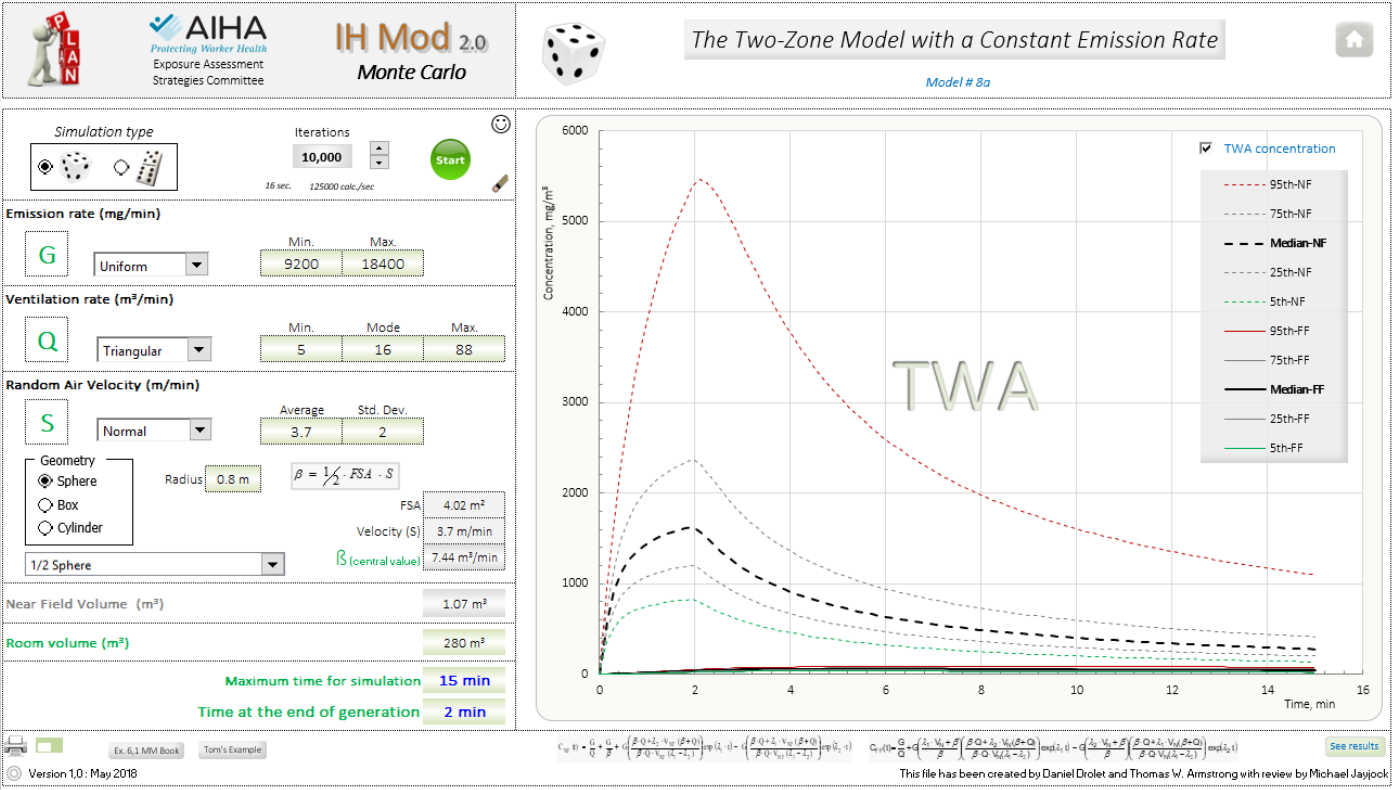
Check here for portion of sphere, or for open sides if a box or cylinder.

Here you define the Near Field shape and calculate Beta. Specify shape, S and FSA, then Beta is set up!
Room Volume adjusts too.



How many iterations do you need? It depends on parameter variability! Start low, run twice and compare the results. If quite divergent, increase the iterations until you have satisfactory “stability” from run to run.

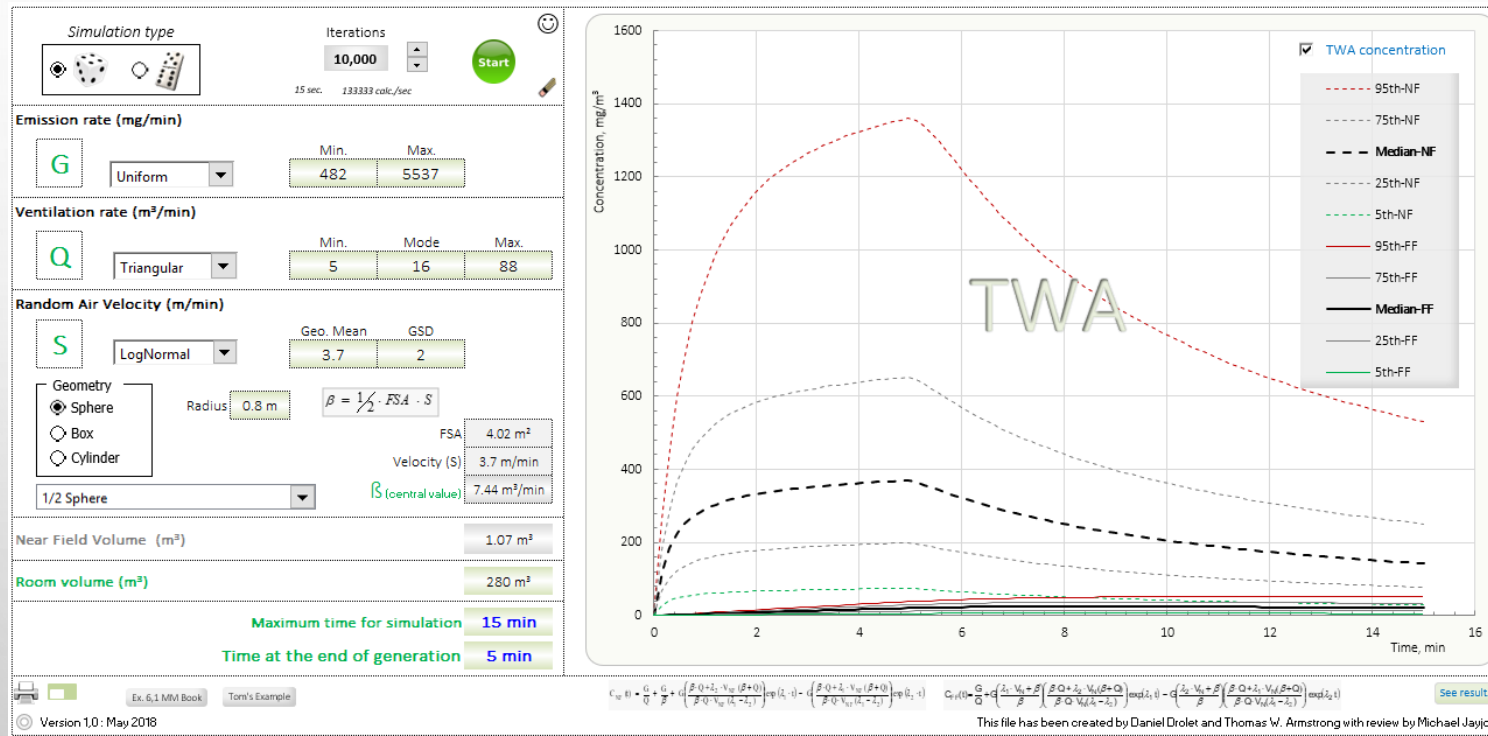
BLANDO 2010 SHOP A 1-BP ADDITION TO MACHINE TWAS TO 15 MINUTES



NEAR FIELD
 15 Min TWA mg/M3
 5th 138
 Median 280
 95th 1098

DRY CLEANING MACHINE UNLOADING TASK EXPOSURE

MODIFIED FROM APP K, EPA DOCUMENT# 740-R1-5001 FEBRUARY 2016



Near Field mg/M3	
5 th	35
Median	151
95 th	593

Estimated 8 hr TWA solvent addition + 14 unloads
 Median 86 mg/M3 (17 ppm) 95th 321 mg/M3 (64 ppm)
 BLANDO measured 8 hr TWA AM 32 ppm, 95th 82 ppm

IH SKINPERM PROGRAM INTRODUCTION SCREEN

The "Read Me" file contains a lot of valuable guidance

This figure shows the major considerations modeled

IH SkinPerm

The goal in developing IH SkinPerm was to help increase understanding of dermal absorption and provide a practical tool to estimate dose from dermal exposure.

The science and terminology associated with dermal exposure estimation may initially seem complex.

We hope the diagrams, explanations, and graphs will promote basic understanding and better knowledge to help target where dermal exposure prevention considerations should be emphasized.

Getting started is easy, simply click on the arrow to navigate from this introduction page to the data input sheet.

Substance selection and scenario types are the initial parameters decided. Scenario choices include instantaneous or deposition over time exposure conditions.

For further information visit [Inside AIHA Exposure Assessment Strategies Committee for a link to the Dermal Project Team web page.](#)

Version 2.04

Translation partner(s): [inrs](#)

comments

Deposition
Vapor pressure
Molecular weight
Substance

Evaporation
Vapor

Loading into stratum corneum
SC/water penetration
Diffusivity
Thickness
Stratum Corneum

Absorption
Water (vehicle) solubility
Viable epidermis

To Systemic Circulation

Here is the entry to the model

Many compounds are in the database with all required physical chemical properties

SKINPERM DATA INPUT SCREEN

Note four scenario variants can be modeled

The user sets the loading factors and affected area here

Exposure Assessment Strategies Committee

IH SkinPerm

Data input

1 Substance selection

Choose substance

Database SkinPerm User's

Benzylalcohol (100-51-6)

add a new substance ...

2 Scenario parameters

Instantaneous deposition Vapor to skin scenario

Deposition over time From water solution

Instantaneous deposition dose	100 mg
Affected skin area	250 cm ²
Maximum skin adherence	7 mg/cm ²
Dermal deposition rate	1 mg/cm ² /hr
Air concentration	1 mg/m ³
Thickness of stagnant air	1 cm
Weight fraction	1.00E+00
Concentration in water	0.00162 mg/L
Thickness of water layer	1000 cm

3 Timing parameters

Start deposition 0 hr

Duration of deposition 0 hr

End time observation 3 hr

4 Report parameters

Calculation intervals/hour 10000

Report intervals/hour 200

START RESET

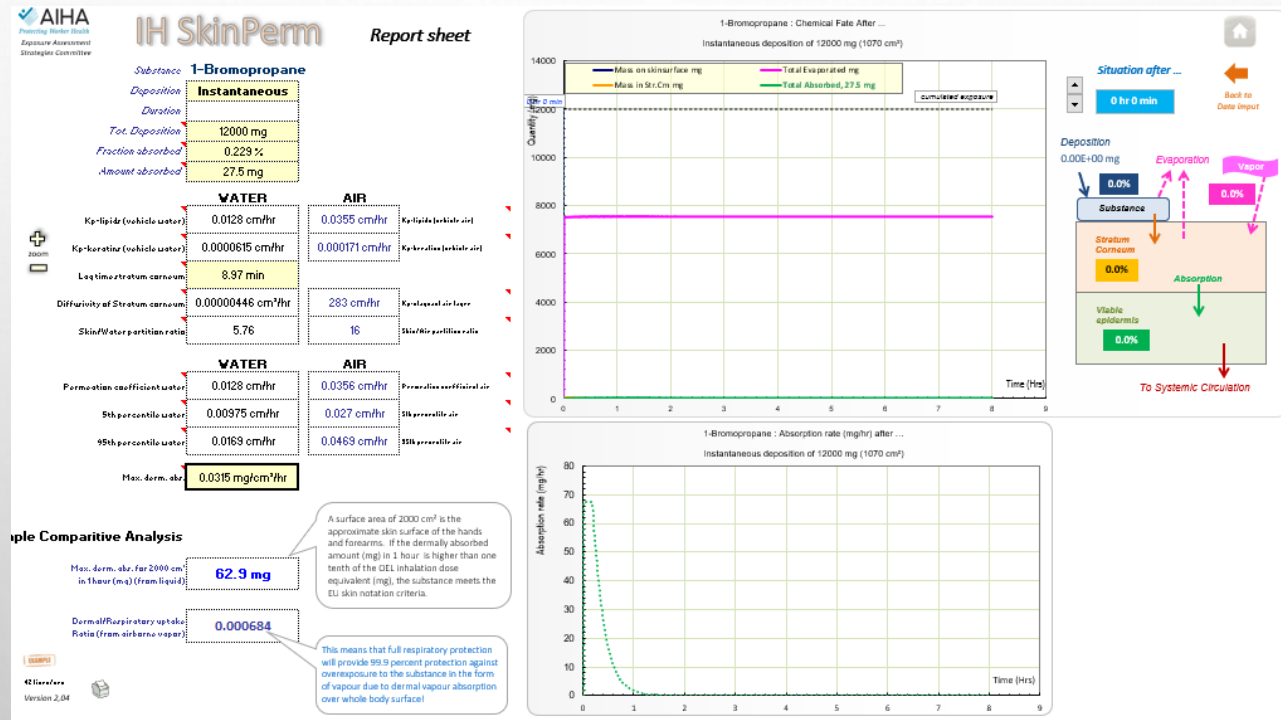
Version 2.04

Users can enter new substances if the physical chemical properties are available

Red triangles indicate some explanation is available

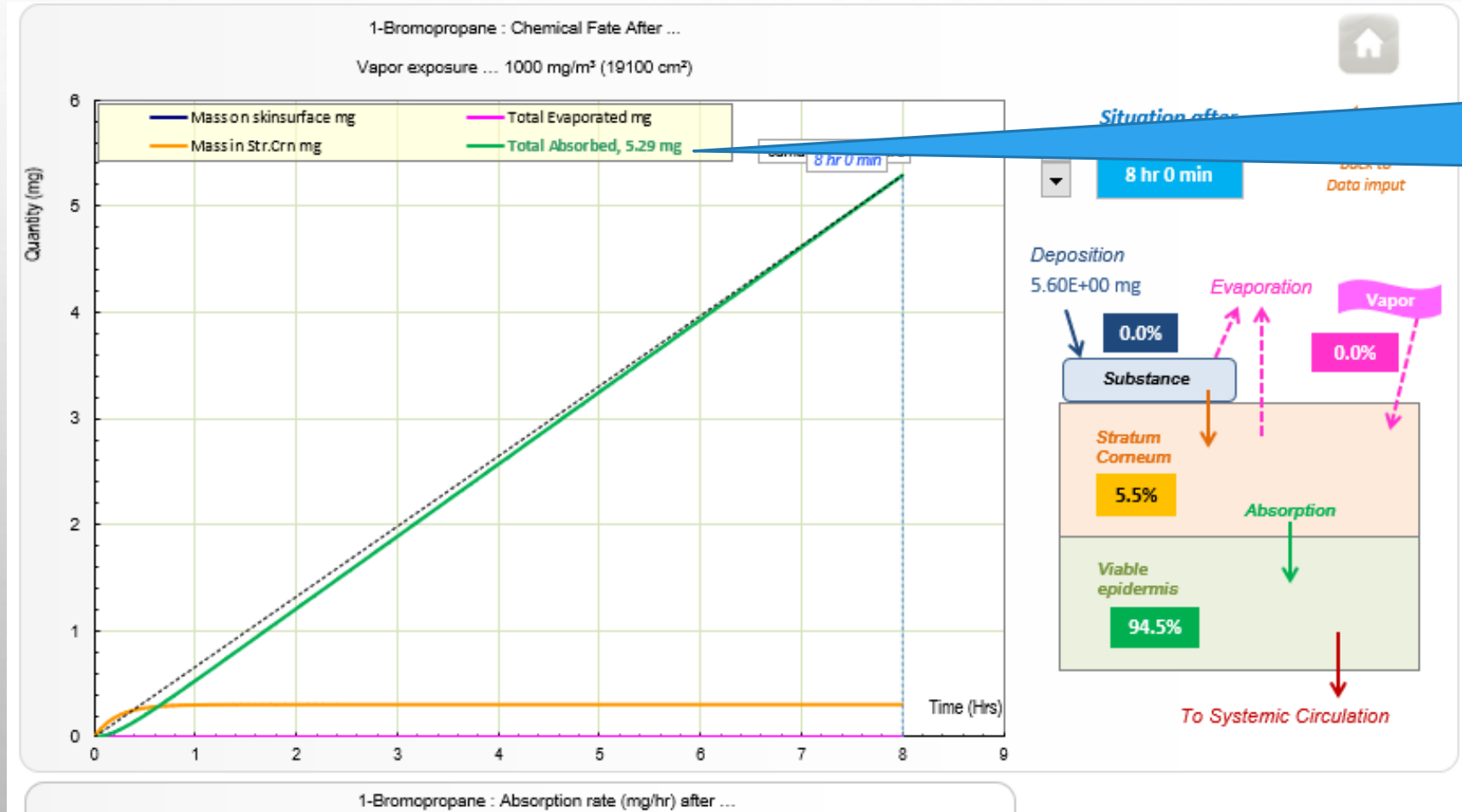
IH SKINPERM TYPICAL RESULTS SCREEN.

WHAT IS SHOWN VARIES WITH THE INITIAL SCENARIO CHOICE. THIS IS FOR 1-BP TO BOTH HANDS. BASICALLY IT ALL EVAPORATES!



IH SKINPERM 1 BROMOPROPANE AIR TO SKIN

FULL ADULT MALE SKIN SURFACE (19100 CM²) AND 1000 MG/M³ AIR CONCENTRATION (200 PPM)



5.3 mg absorbed for 8 hours

IN SUMMARY

THE TOOLS REVIEWED ARE FREEWARE, ARE OPENLY AVAILABLE AND PROVIDE EASY TO USE APPROACHES TO IMPORTANT ASPECTS OF THE EXPOSURE ASSESSMENT PROCESS

- SCENARIO DEFINITION AND DOCUMENTATION OF KEY EXPOSURE DETERMINANTS
- QUALITATIVE EVALUATION VIA JUDGEMENT HEURISTICS
- STATISTICAL EVALUATION OF SURVEY DATA
- MODELING OF DERMAL UPTAKE INCLUDING FROM AIR
- EITHER DETERMINISTIC OR MCS SIMULATION WITH MULTIPLE ALGORITHMS FOUND USEFUL FOR OCCUPATIONAL OR DOWNSTREAM USER SCENARIO EVALUATION

THE AIHA EASC TEAM INVOLVED IN DEVELOPING TOOLS WELCOMES COLLABORATION ON THEIR FURTHER DEVELOPMENT AND FOR TRANSLATIONS OF THE MULTI-LINGUAL TOOLS