The Exposure Science Frontier

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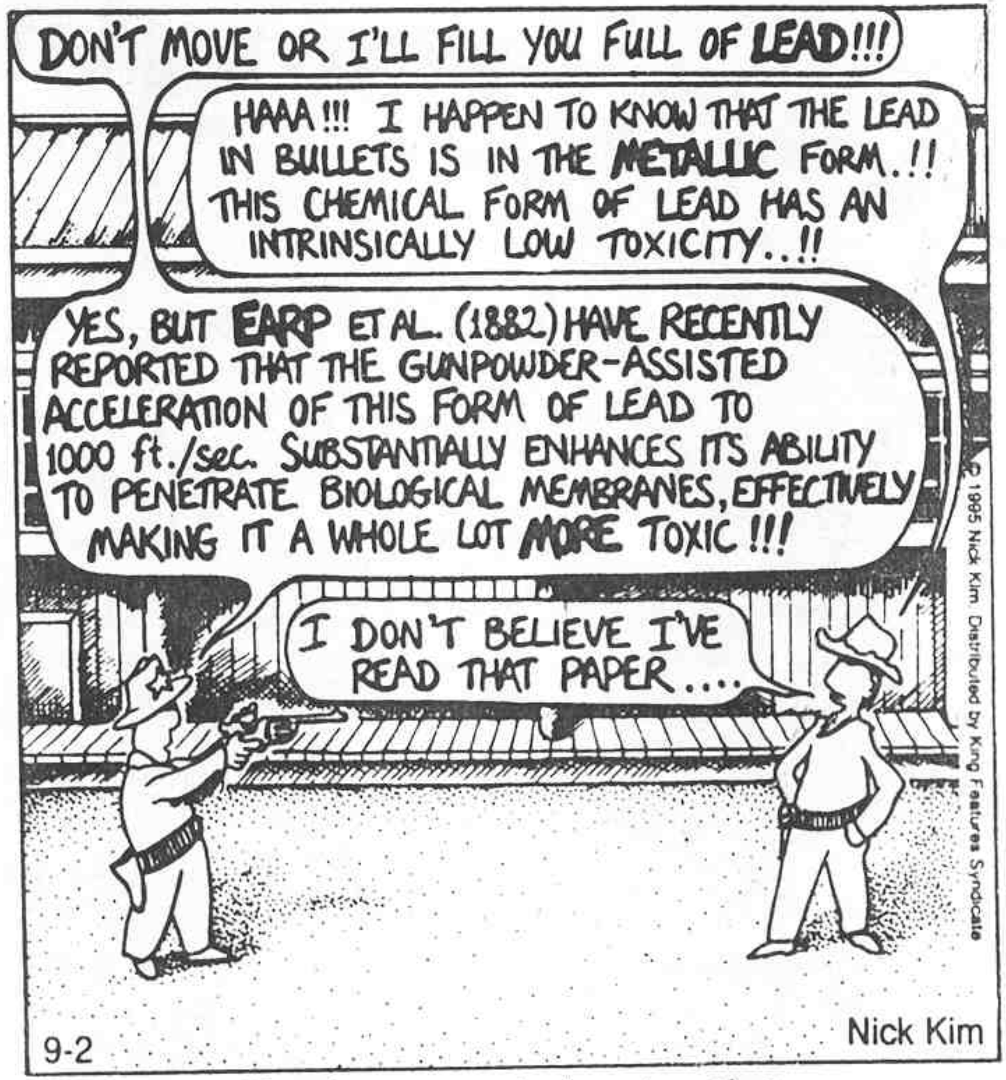
Insight Exposure and Risk Sciences

December 5, 2017

insight exposure & risk sciences

10B The Cincinnati Post, Saturday, September 2,

The New Breed



Environmental scientists
in the Wild West.

Exposure Science: Overview

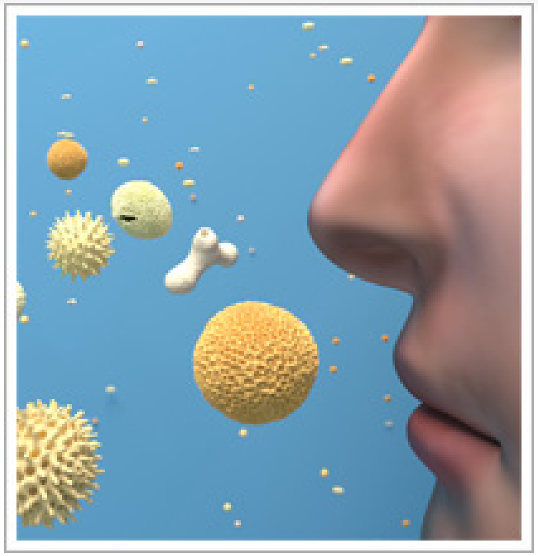
- Types of Exposures
- New and Cutting Edge Methods of Exposure Analysis
  - Sensor Technologies
  - Big Data
  - Statistical Analysis
  - Monte Carlo Analysis
  - Bayesian Decision Analysis

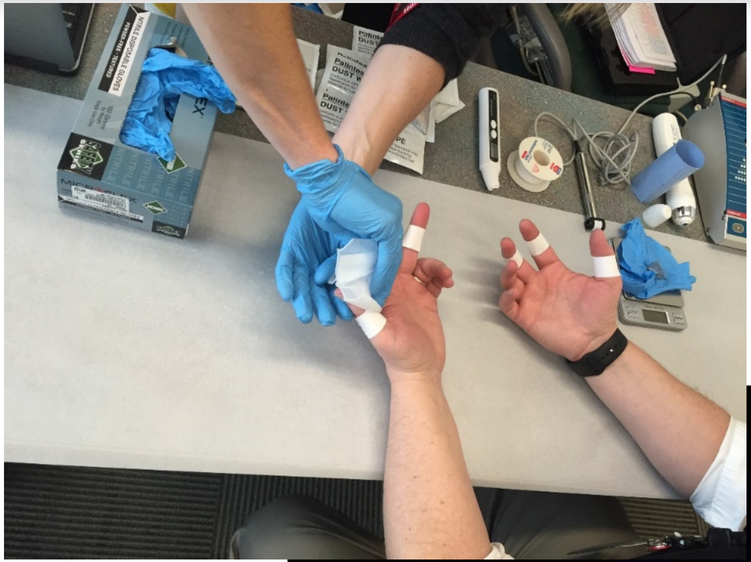
Exposure Classification is Important!

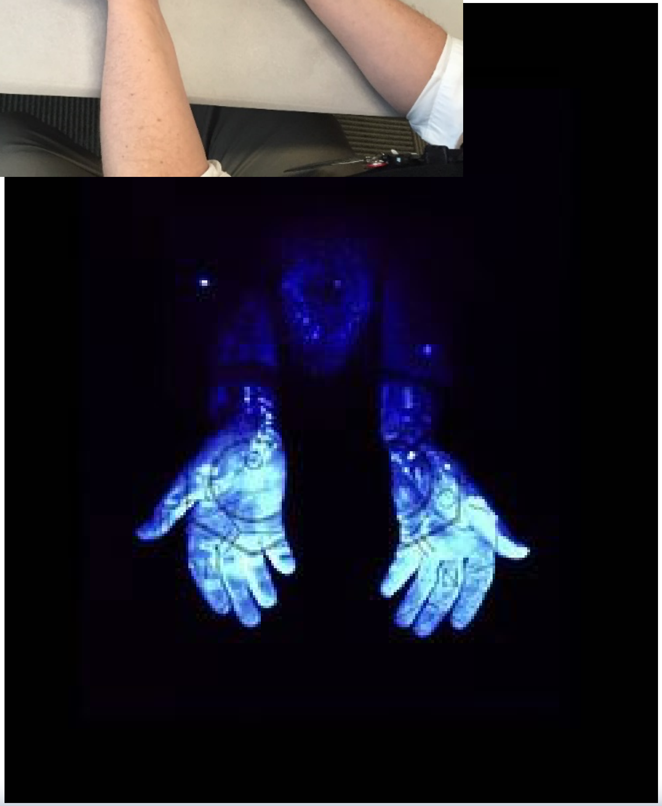
- Recent studies have highlighted the effects of **exposure misclassification** on
  - Can be the most important confounding factor in an epidemiology study
  - We must continue to improve exposure science to get exposure classification correct

Types of Exposures

Routes of Exposure





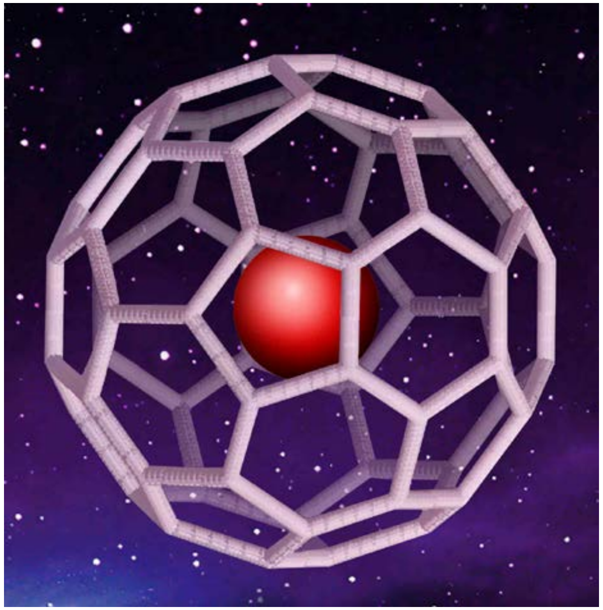


Routes of Exposure

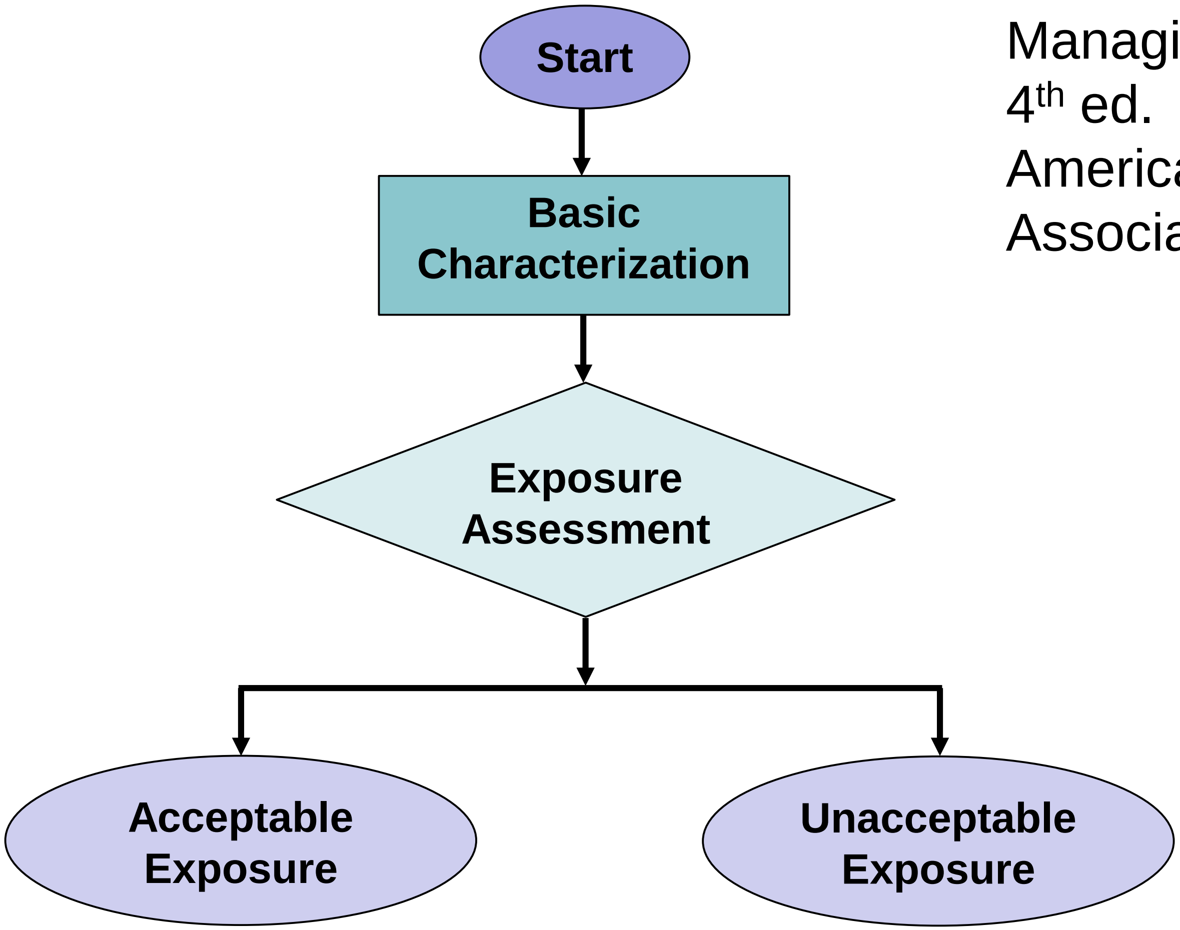
- Inhalation
  - Gases, Aerosols, Particulates

- Dermal (Liquids and Solids)
- Ingestion (Hand to Mouth)

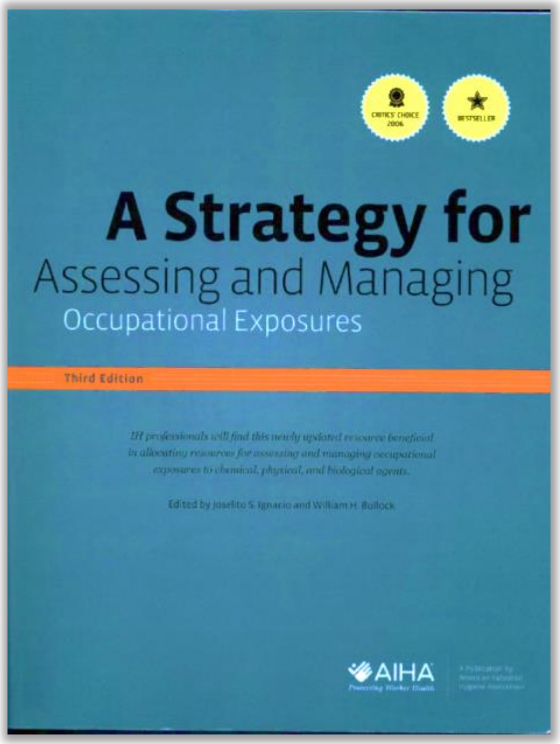
Methods of Exposure Analysis: New and Cutting Edge Approaches



AIHA's Exposure Assessment Strategy



A Strategy for Assessing and Managing Occupational Exposures, 4th ed. Ignacio and Bullock (eds). American Industrial Hygiene Association, Fairfax, VA. 2015.



Selecting the Best Approach for Assessing Exposures

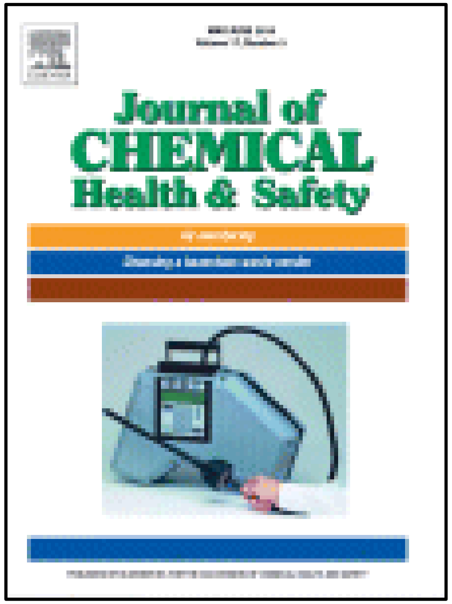
- Quantitative Approaches
- Semi-quantitative Approaches
- Qualitative Approaches
- Combination Approaches

Quantitative Approaches

- Use of exposure data
  - historical personal exposure data
  - current personal exposure data
  - area data as a surrogate for personal exposures
  - simulated exposure scenarios
  - biological monitoring data

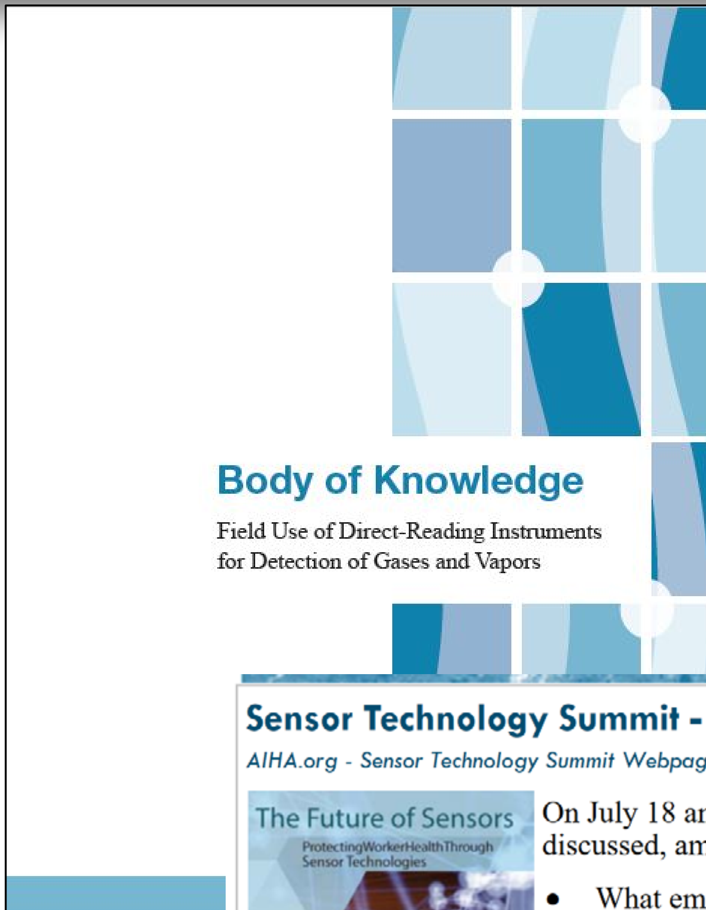
Types of Direct Reading Instruments

- Gas and vapor methods
- Colorimetric Devices
  - Active
  - Passive
- Instruments
  - Galvanic
  - Thermochemical
  - Electrochemical
  - Spectrochemical
- Aerosol methods
- Colorimetric Methods
- Optical Particle Monitors
  - Photometers
  - Condensation particle counters
  - Wide-range aerosol spectrometer
- Tapered Element Oscillating Microbalance
- Time-of-flight Mass Spectrometry
- Beta Attenuation
- Scanning Mobility Particle Sizer/Differential Mobility Particle Sizer
- Aerodynamic Particle Sizer
- Fiber Monitors



Quantitative Approaches: Direct Reading Instruments

Sensor Technologies and Direct Reading Instruments



ELSEVIER
Journal of Chemical Health and Safety
Volume 17, Issue 3, May–June 2010, Pages 10-21

Feature

Direct-reading methods for workplace air monitoring ☆

Christopher C. Coffey, Terri A. Pearce

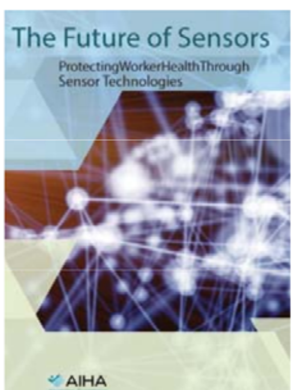
⊞ Show more

https://doi.org/10.1016/j.jchas.2009.08.003

Direct-reading methods (DRMs) are valuable tools for detecting and measuring worker exposure to inhalation hazards. A DRM can be either a device or instrument capable of measuring gases and vapors and aerosols such as dusts, fumes, and mists without manipulation of the sample by the user or sending the sample to an offsite laboratory. Devices are those DRMs that are simple, single point in time measurement of exposure. Instruments are DRMs that contain a sampling system, signal-processing electronics, a display system, and a

Sensor Technology Summit - The Future of Sensors

AIHA.org - Sensor Technology Summit Webpage



On July 18 and 19, 2016 at the AIHA offices in Falls Church, VA, this unprecedented Summit discussed, among many other questions, the following:

- What emerging sensing technologies are relevant to industrial hygiene?
- What if you had access to validated direct read instrumentation, specific to the needs of the industrial hygienist, which incorporated the latest sensing technologies?
- What improvements to detection, monitoring, prediction – and worker health – might be possible by 2021?
- What changes in hazard sensing - performance, regulation, access, and education - are needed to make that 2021 vision a reality?

Quantitative Approaches: Big Data

Most IHs work with very limited data points—many of us would be happy with, say, six measurements of a worker's exposure. Now think of a future with six measurements *per second*.

the synergist

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Synergist® Solutions: Big Data

Big Data in Occupational Hygiene

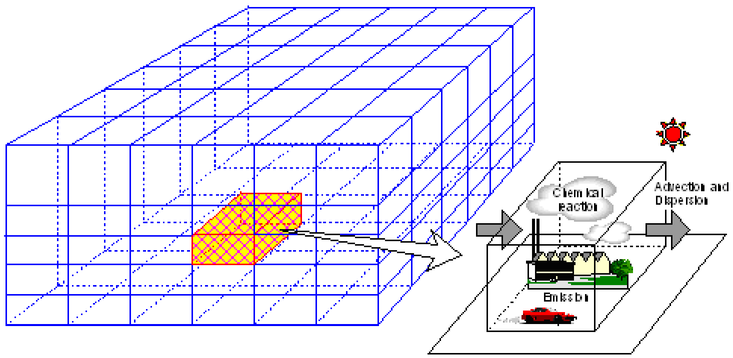
By Peter Briscoe

Humans are visual beings. Fully two-thirds of our brains' processing ability is engaged with visualizing our wo
result is that we can make better decisions much faster if the information to make those decisions is in a visu

For the past 40 years, communication and computing power has improved to the point that we can create vi
for almost any type of data. Today there is a vast, ever-expanding volume of data available for any number o
applications. The prevalence of large, complex datasets has given rise to the term "big data." Using these lar
can lead to more confident decision making and better decisions, resulting in greater operational efficiency,
reduction, and reduced risk.

Semi-Quantitative Approaches

- Use of exposure data matrices or job exposure matrices (JEMs)
- Use of exposure determinants
  - ventilation system and rates
  - work practices
  - type of equipment used
- Data interpolation or estimation to fill gaps
- Mathematical modeling methods
  - single zone, two zone



IH MOD

AIHA
Protecting Worker Health

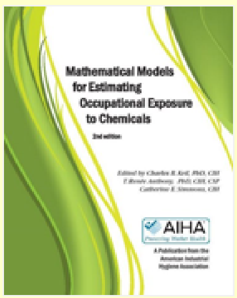
IH Mod

Comité de estrategias de evaluación de la exposición, AIHA

Español

Esta hoja de cálculo Excel contiene numerosos algoritmos útiles para el cálculo de la concentración de una sustancia química en el ambiente. Las formulas y/o ecuaciones incluidas en la presente hoja de cálculo han sido ya definidas en la literatura. El signo de interrogación en verde es un hipervínculo que permite el acceso a las informaciones destinadas a los usuarios así como a la ayuda general.

Los usuarios consultarán esta herramienta como una fuente de información acerca de los límites y aplicaciones de los algoritmos. Los usuarios son responsables de la revisión, la comprensión y la transmisión de las limitaciones de todas las evaluaciones efectuadas con la ayuda de la presente hoja de cálculo



Charles B. Keil
Catherine Simmons
T. Renée Anthony
Ed. AIHA Press

Versión 0.212

Selección de modelo

Modelo de área con aire uniformemente mezclado y tasa de emisión constante

If this file doesn't work

Comité EASC

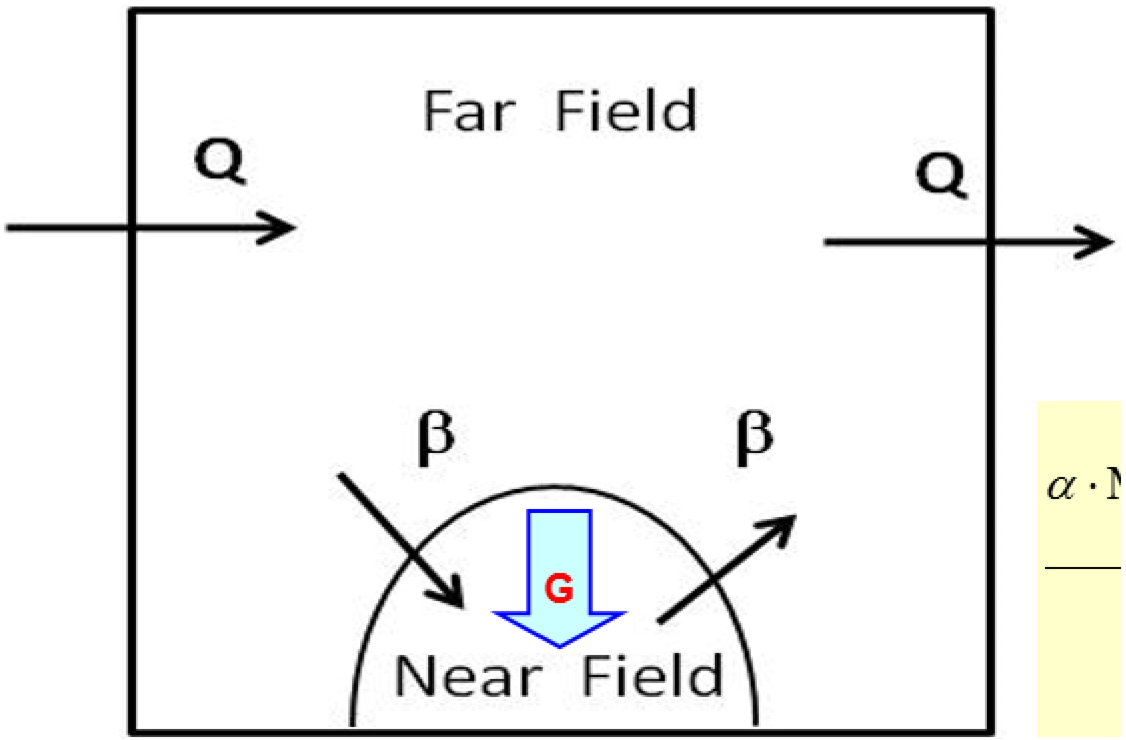
Colaboradores de traducción

inrs · ist · University of Minnesota School of Public Health · Université de Montréal

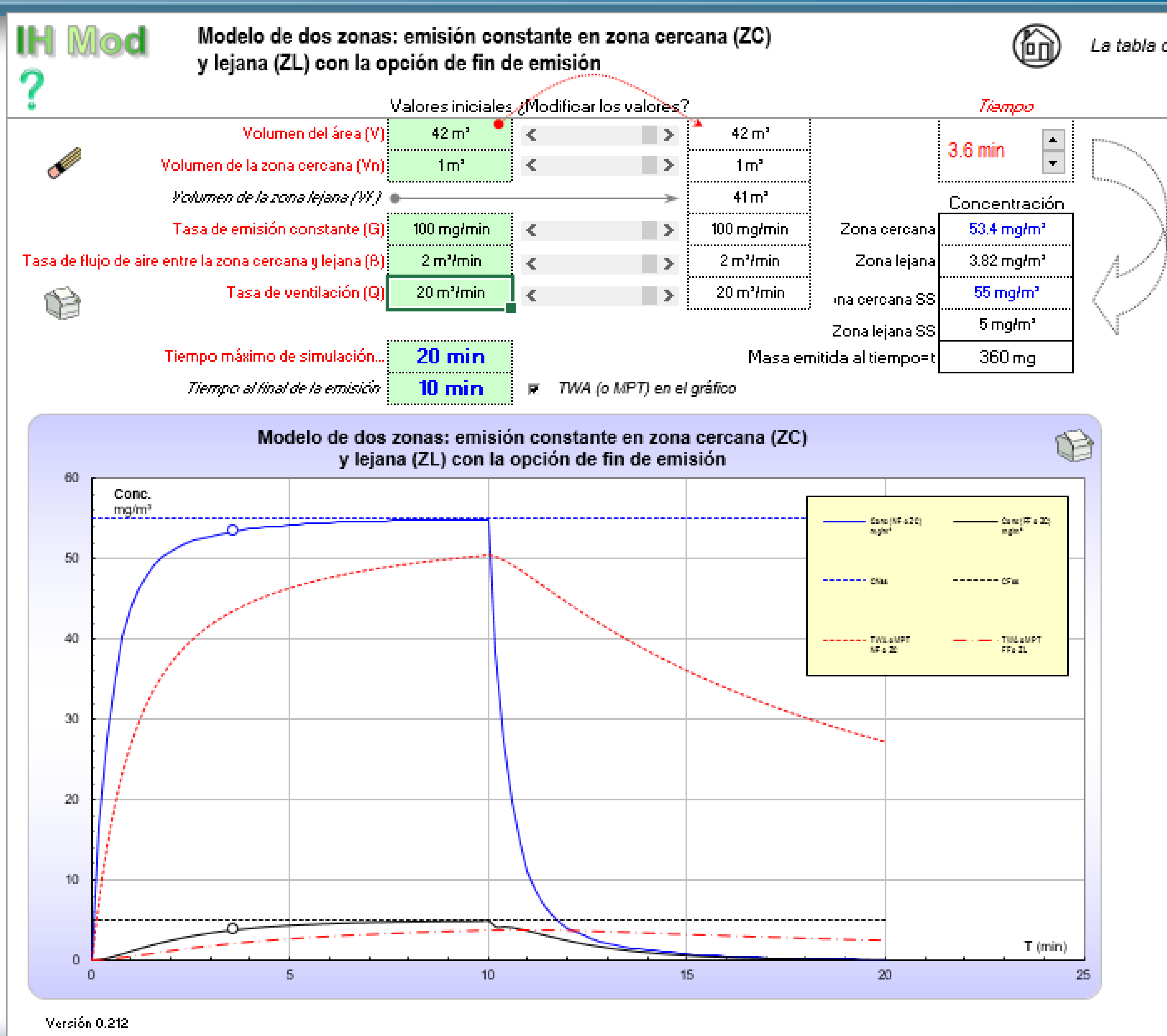
Pestañas visibles (si/no)

Descargo de responsabilidad

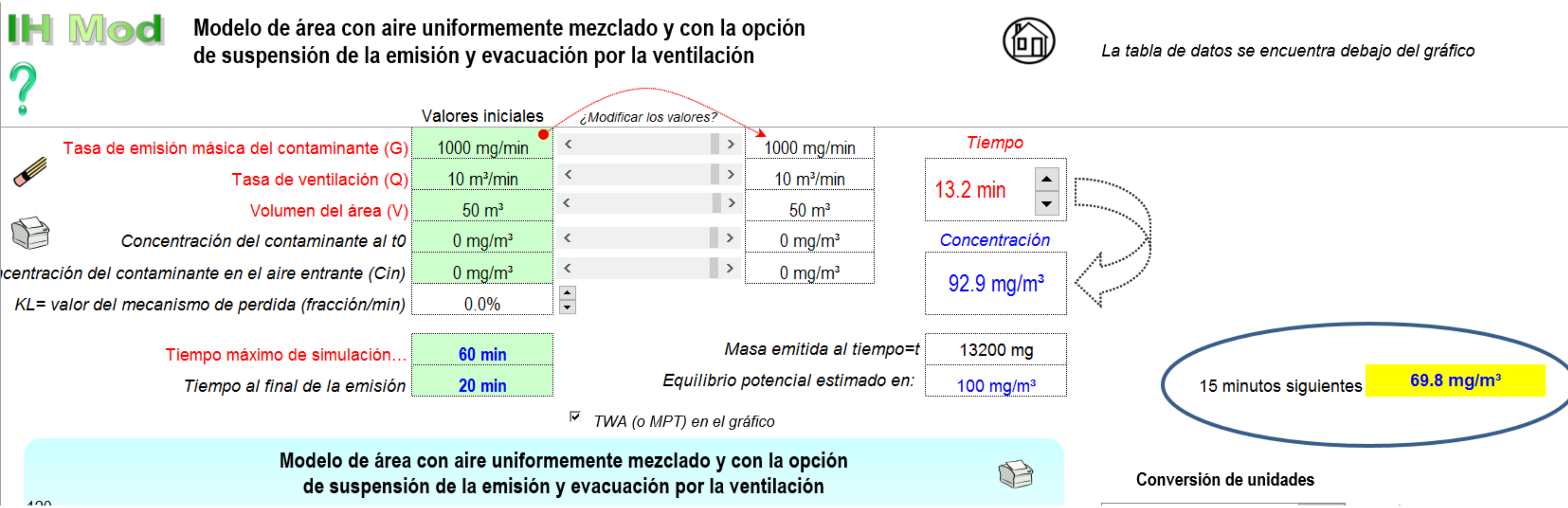
IH MOD



IH MOD


IH Mod
?
Modelo de dos zonas: emisión constante en zona cercana (ZC)
y lejana (ZL) con la opción de fin de emisión
La tabla de
Valores iniciales ¿Modificar los valores?
Tiempo
Volumen del área (V) 42 m³ 42 m³
3.6 min
Volumen de la zona cercana (Vn) 1 m³ 1 m³
Volumen de la zona lejana (Vf) 41 m³
Concentración
Tasa de emisión constante (G) 100 mg/min 100 mg/min
Zona cercana 53.4 mg/m³
Tasa de flujo de aire entre la zona cercana y lejana (B) 2 m³/min 2 m³/min
Zona lejana 3.82 mg/m³
Tasa de ventilación (Q) 20 m³/min 20 m³/min
ına cercana SS 55 mg/m³
Zona lejana SS 5 mg/m³
Tiempo máximo de simulación... 20 min
Masa emitida al tiempo=t 360 mg
Tiempo al final de la emisión 10 min
TWA (o MPT) en el gráfico
Modelo de dos zonas: emisión constante en zona cercana (ZC)
y lejana (ZL) con la opción de fin de emisión
Conc.
mg/m³
60
50
40
30
20
10
0
0
5
10
15
20
25
T (min)
Versión 0.212

IH MOD


IH Mod
Modelo de área con aire uniformemente mezclado y con la opción de suspensión de la emisión y evacuación por la ventilación
La tabla de datos se encuentra debajo del gráfico
Valores iniciales
¿Modificar los valores?
Tasa de emisión másica del contaminante (G)
1000 mg/min
1000 mg/min
Tasa de ventilación (Q)
10 m³/min
10 m³/min
Volumen del área (V)
50 m³
50 m³
Concentración del contaminante al t0
0 mg/m³
0 mg/m³
centración del contaminante en el aire entrante (Cin)
0 mg/m³
0 mg/m³
KL= valor del mecanismo de perdida (fracción/min)
0.0%
Tiempo
13.2 min
Concentración
92.9 mg/m³
Tiempo máximo de simulación...
60 min
Tiempo al final de la emisión
20 min
Masa emitida al tiempo=t
13200 mg
Equilibrio potencial estimado en:
100 mg/m³
15 minutos siguientes
69.8 mg/m³
TWA (o MPT) en el gráfico
Modelo de área con aire uniformemente mezclado y con la opción de suspensión de la emisión y evacuación por la ventilación
Conversión de unidades

IH STAT

Estadísticas de Higiene Ocupacional

LEO o OEL
0.15

Datos
0.06
0.1
0.05
0.1
0.01
0.09
0.04
0.2
0.04
0.08
0.08
0.03
0.09
0.03
0.07

??

Estadística descriptiva

Número de muestras (n)	15
Máximo (máx.)	0.2
Mínimo (min.)	0.01
Rango	0.19
Media	0.0713
Mediana	0.07
Desviación Estándar (s)	0.0453
Media geométrica	0.0584
Desviación estándar geométrica DEG	2.03
Porcentaje por encima del LEO	6.7%

'rueba de ajuste de una distribución

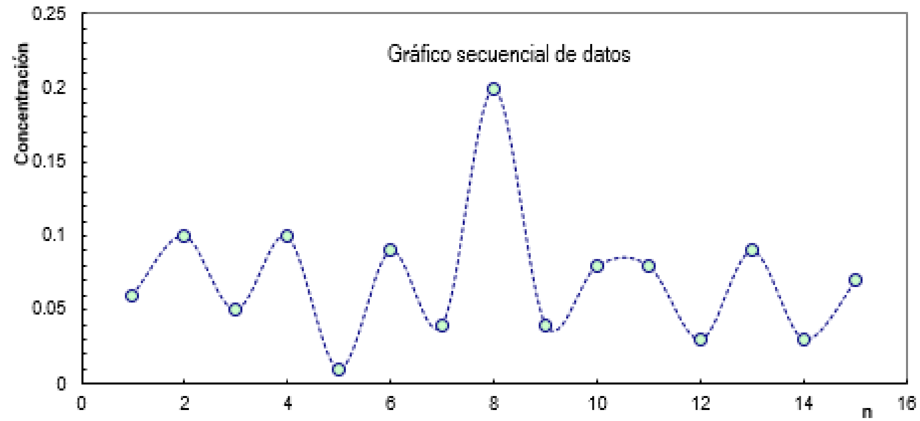
Prueba W de datos log-transformados	0.932
Log-Normal (α = 0.05)?	**Si**
Prueba o Test-W de datos	0.870
Normal (α = 0.05) ?	**No**

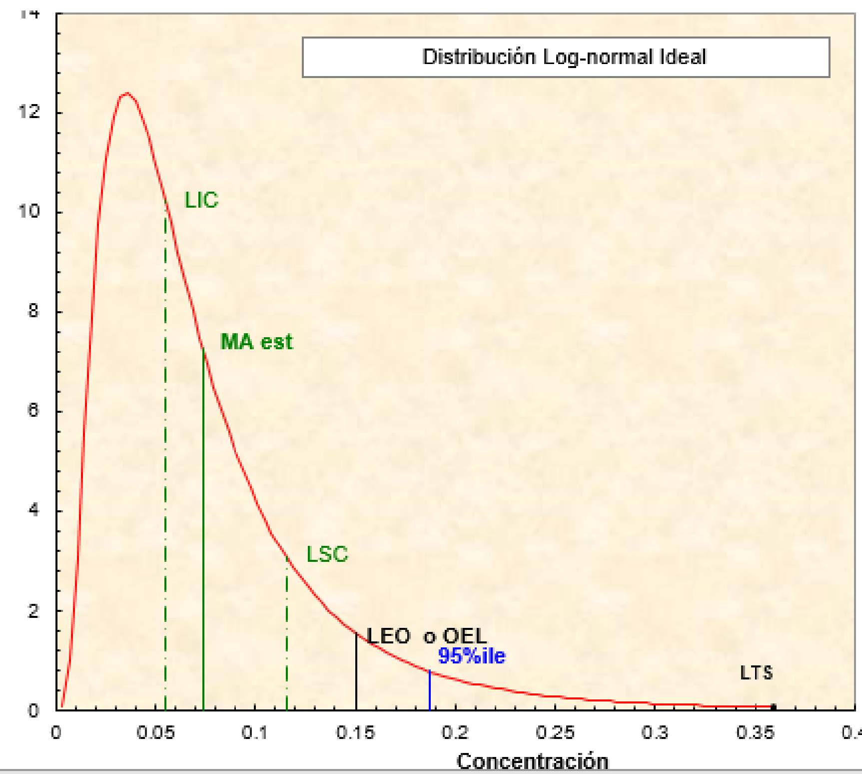
: paramétricas para distribuciones Log-normales

Media aritmética estimada (MA est.)	0.074
LCI1, 95% - Land's "Exacto"	0.055
LCS1, 95% - Land's "Exacto"	0.116
Percentil 95	0.187
LTS 95%, 95%	0.359
Fracción excedente del LEO	9.1%
LCI1, 95%, %>OEL	2.82
LCS1, 95%, %>OEL	23.4

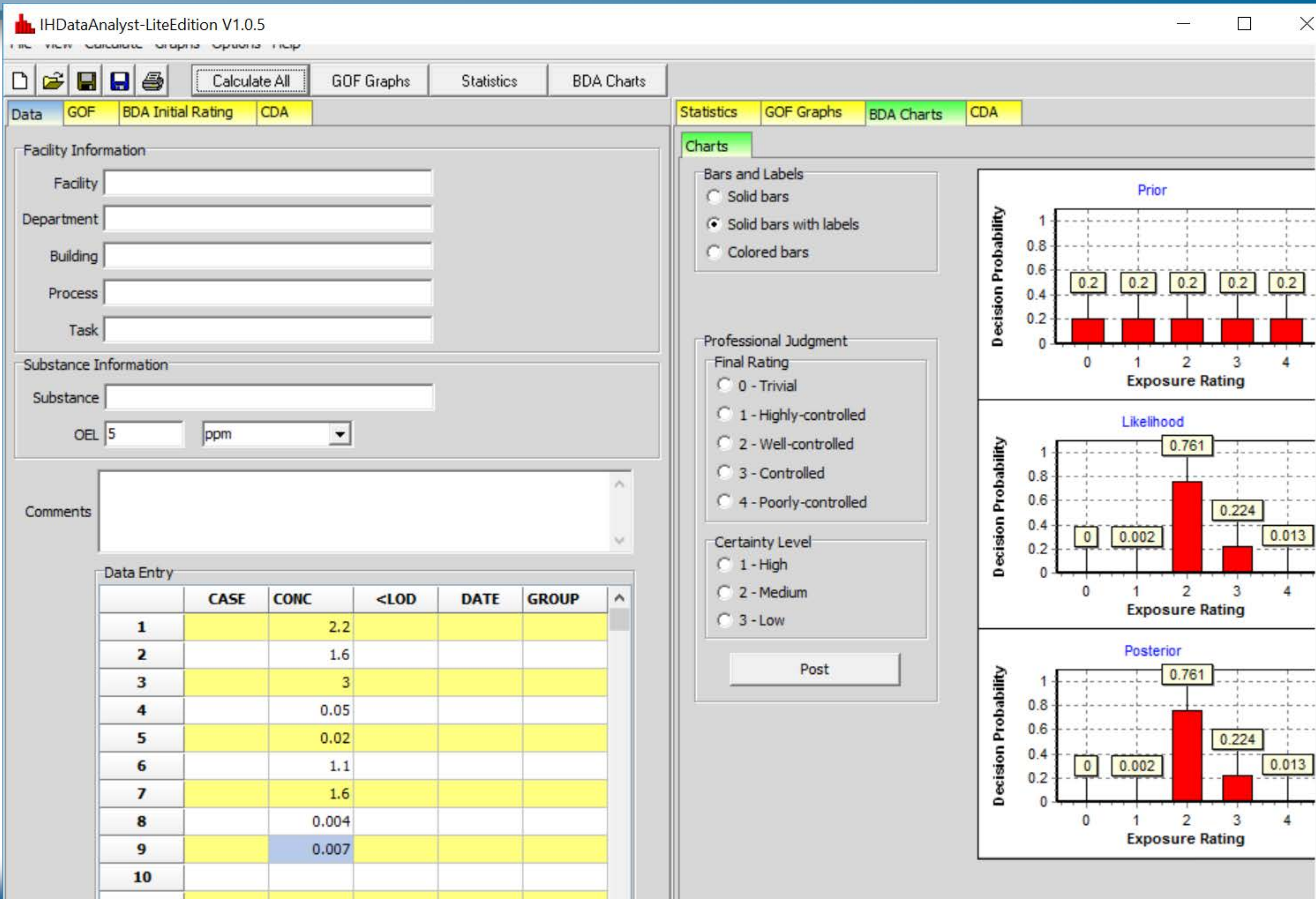
ticas paramétricas para distribuciones normales

Media	0.0713
LCI1, 95% - estadística-t	0.051
LCS1, 95% - estadística-t	0.092
Percentil 95 - Z	0.146
LTS 95%, 95%	0.188
Porcentaje mayor que LEO	4.1%

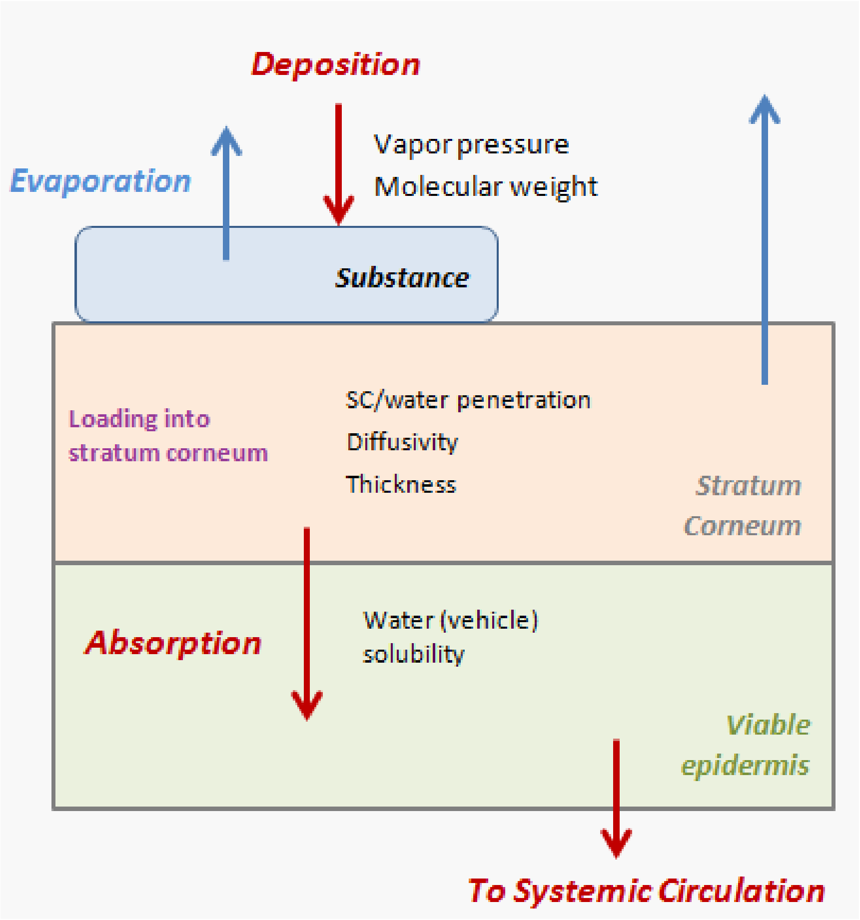




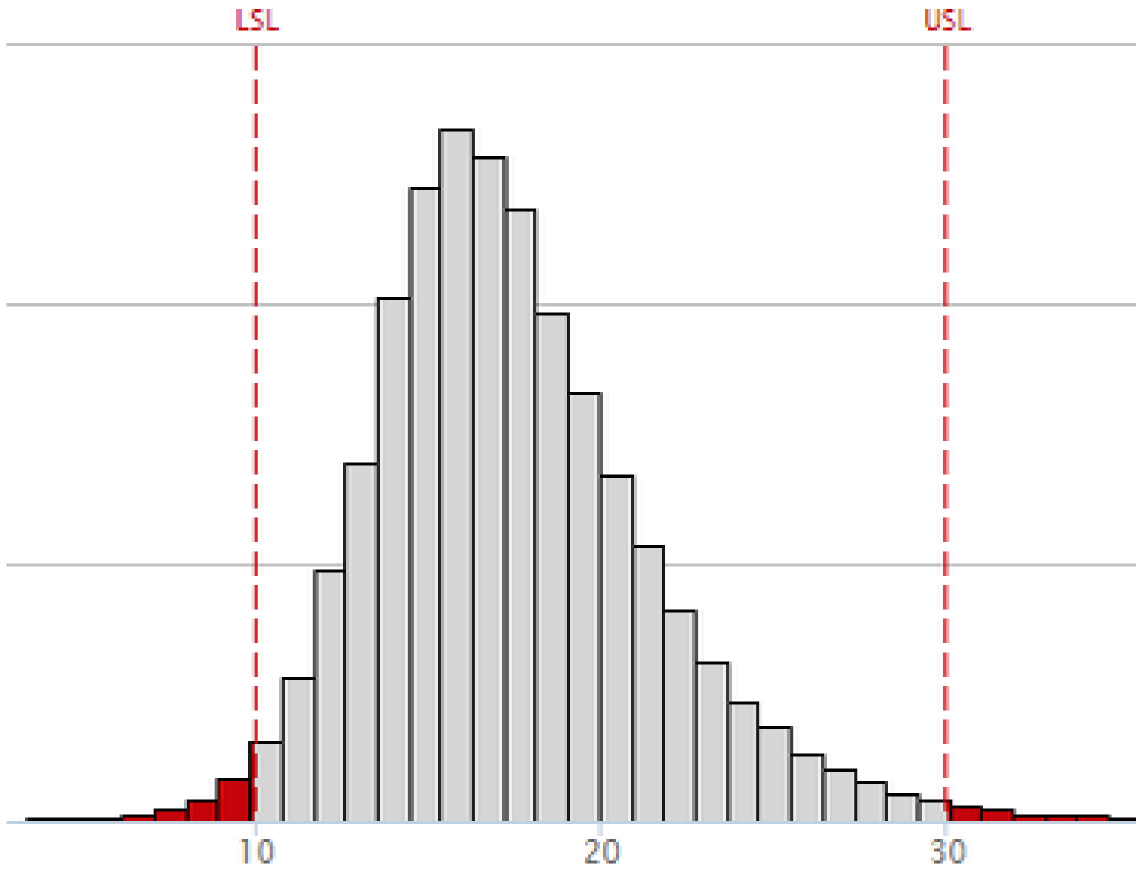
IH Data Analyst (IHDA)



IH SkinPerm: Tools to Estimate Skin Absorption and Penetration



Monte Carlo Analysis



Qualitative Approaches

- Professional judgment
  - review of an existing data set by an expert in a related field
  - Such as industrial hygiene, epidemiology, medicine, toxicology

- Self-reported exposures
  - reliability issues

Combination Methods

- Can be extremely effective
- Often combine multiple data types into one reconstruction
  - Limited sampling data
  - Modeling efforts
  - Exposure information about ventilation and work practices
  - Expert judgment about likely exposures
  - Monte Carlo Analysis
  - Bayesian data analysis (BDA) or IHDA can be used to combine data

Real World Case Studies

NIOSH Case Study: Lead

Goals:

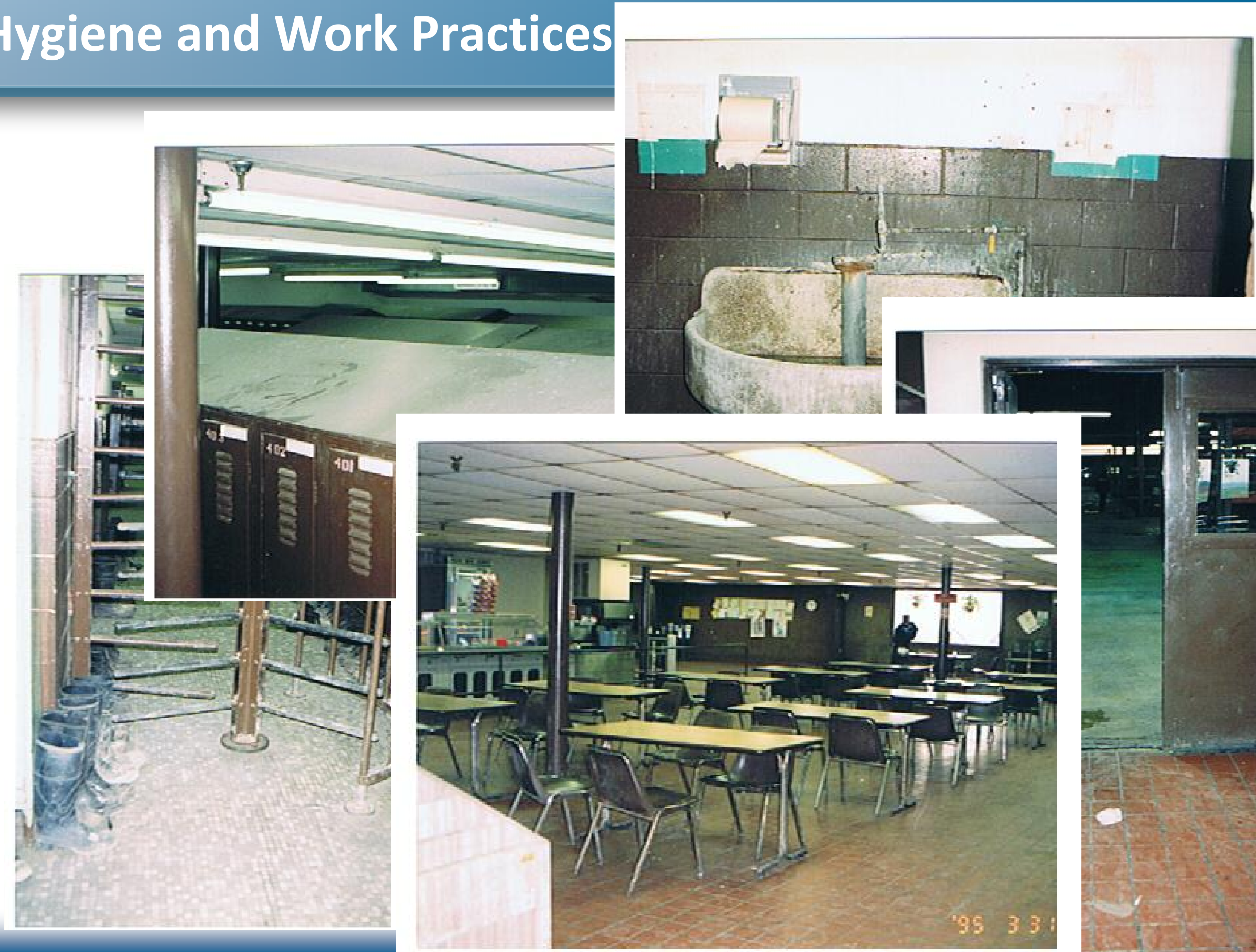
- Identify skin exposures
- Assess risks due to dermal pathway
- Suggest and discuss possible interventions
- Assess the use of biological monitoring as a measure of intervention effectiveness

Who is Exposed?

- Pb: Estimated 600,000 industrial workers, military, law enforcement, recreational shooters, children. 1.5 billion lbs used (1992)
- Cd: Estimated 512,000 workers
- As: Estimated 55,000 workers, 30,000 metric tons used annually.
- Ni: Estimated 727,000 workers, women most affected, beauticians, health care.

ATSDR Tox. Profiles

Hygiene and Work Practices



Personal Protection

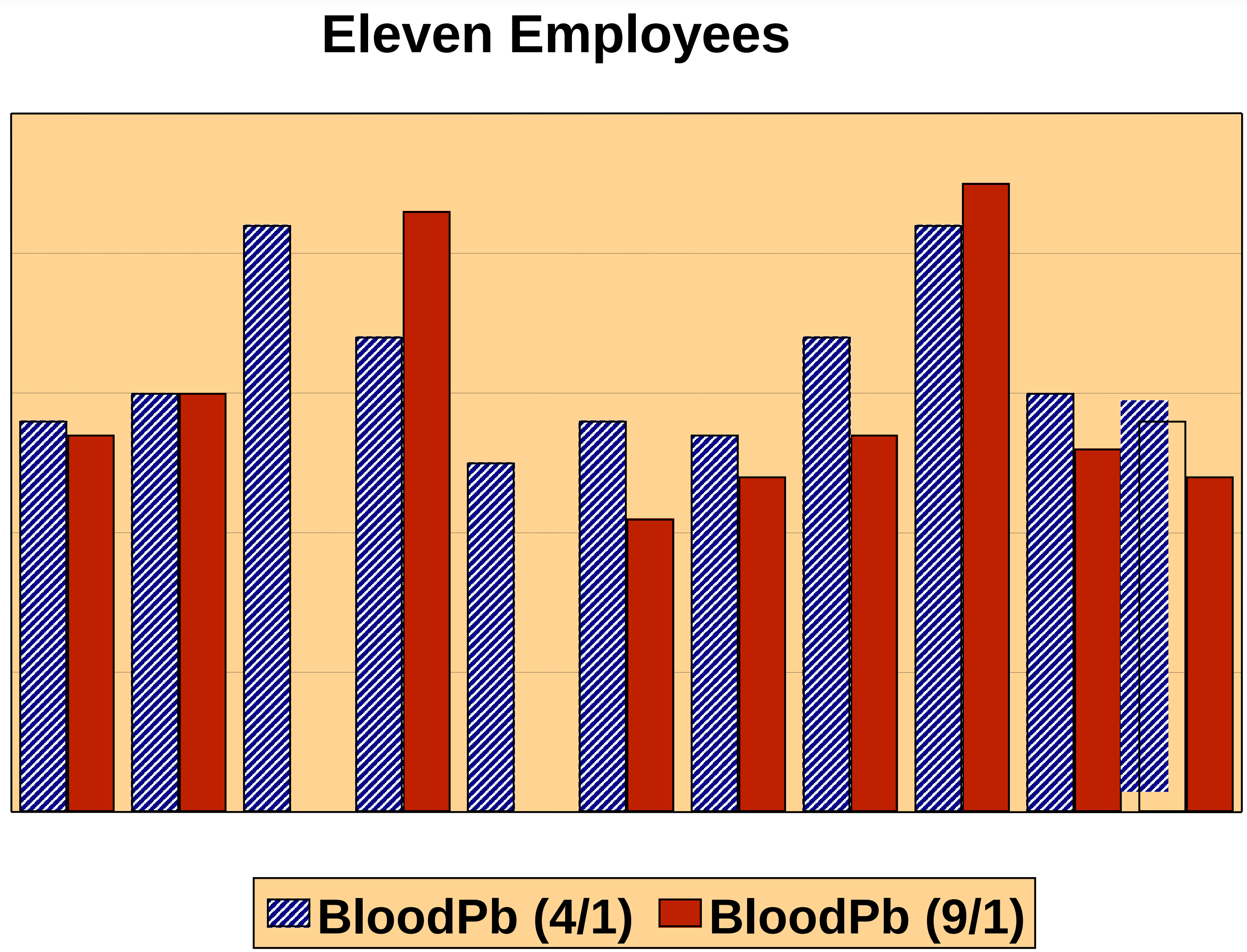
Ventilation Controls

Pb Air Sampling

- 75% (33/44) > OSHA PEL
- Pasting 68 - 495 µg/m^3
- 1st Assy 15 - 418 µg/m^3
- Pouching 31 - 77 µg/m^3
- Grid Casting 12 - 43 µg/m^3

All workers wore respirators, but many had elevated blood leads

Blood Leads on Two Occasions



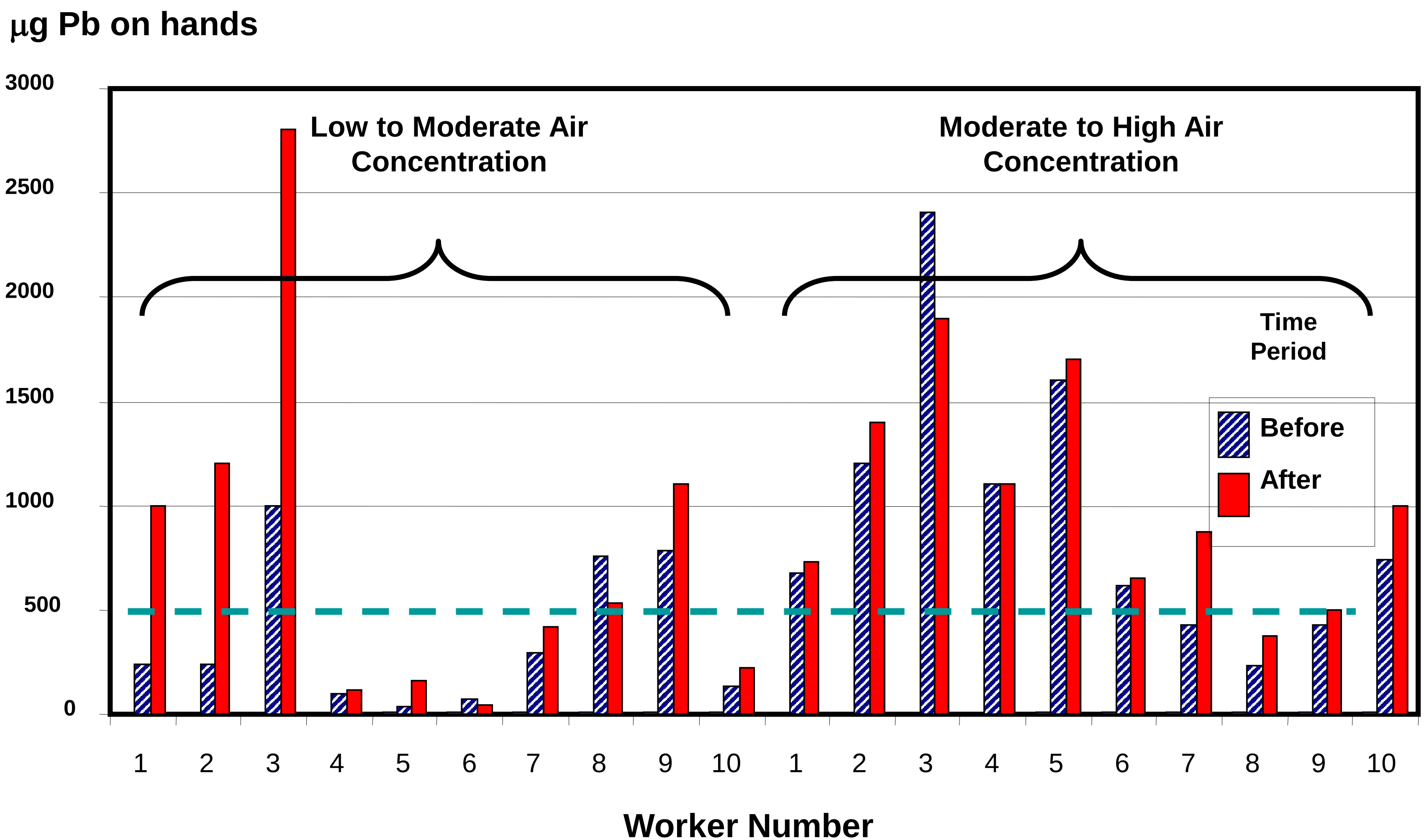
Amount of Pb Loadings sampled from 2 hands

- End of work: 6,000 – 9,000 µg
- Upon arriving at work, Monday:~70 µg
- Upon arriving at work, Tues – Thursday:

~150 µg

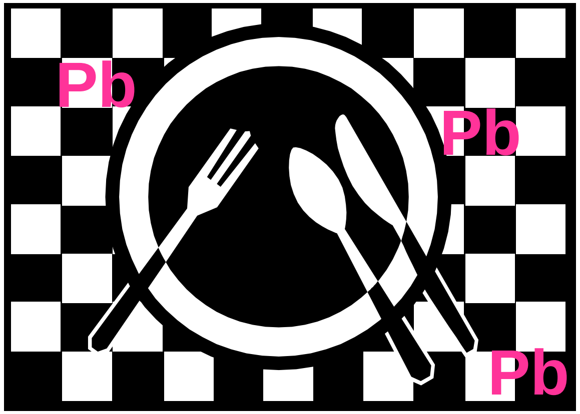
The sampling recovery of experimentally contaminated hands using wet wipes is ~50-60% with one wipe.

After Washing and After Eating in a Cafeteria



Wipe Sampling: Contaminated Surfaces

- Cafeteria Doorknobs 90 – 160 µg/ft^2
- Railing, Food Service Line 3700 µg/ft^2
- Steam Table 140, 320 µg/ft^2
- Cafeteria Tables 140 – 770 µg/ft^2
- 3 Kitchen Cutting Boards 9 – 130 µg/ft^2

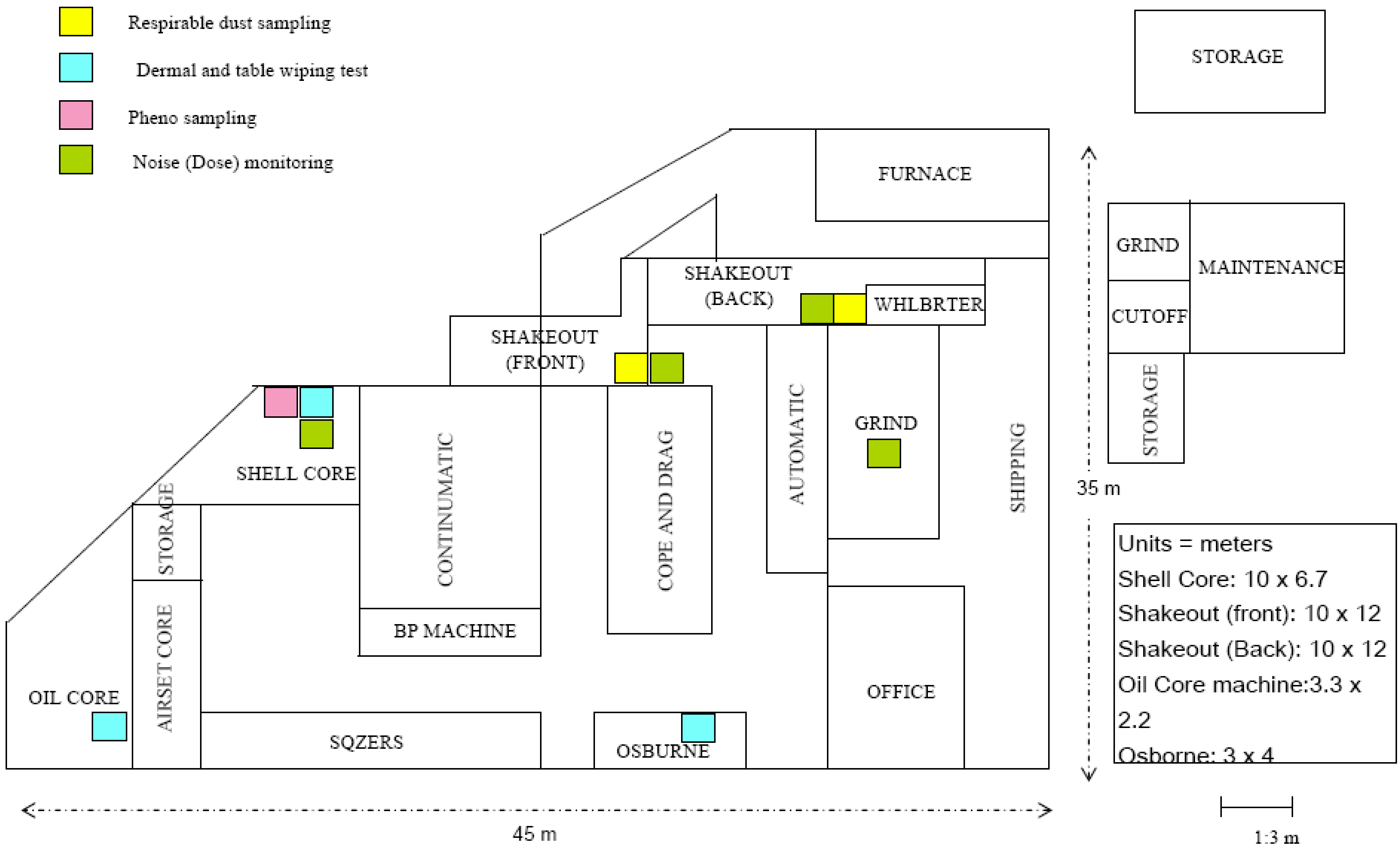


AIHA Exposure Assessment Strategies Committee Case Study – Silica Exposures

Gurumurthy Ramachandran

Susan Arnold

Map of Workplace



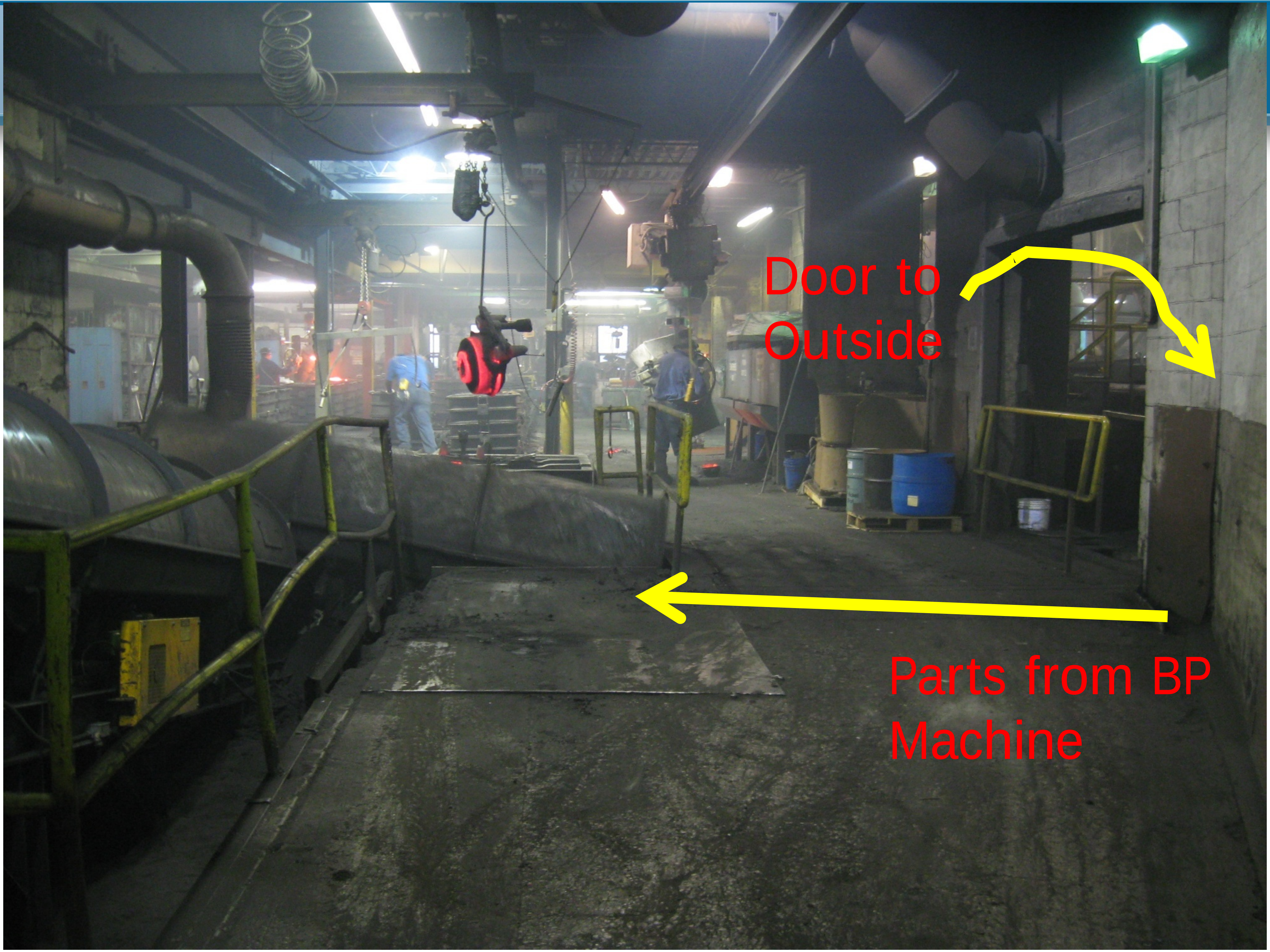
2009 Exposure Assessment Strategies Symposium

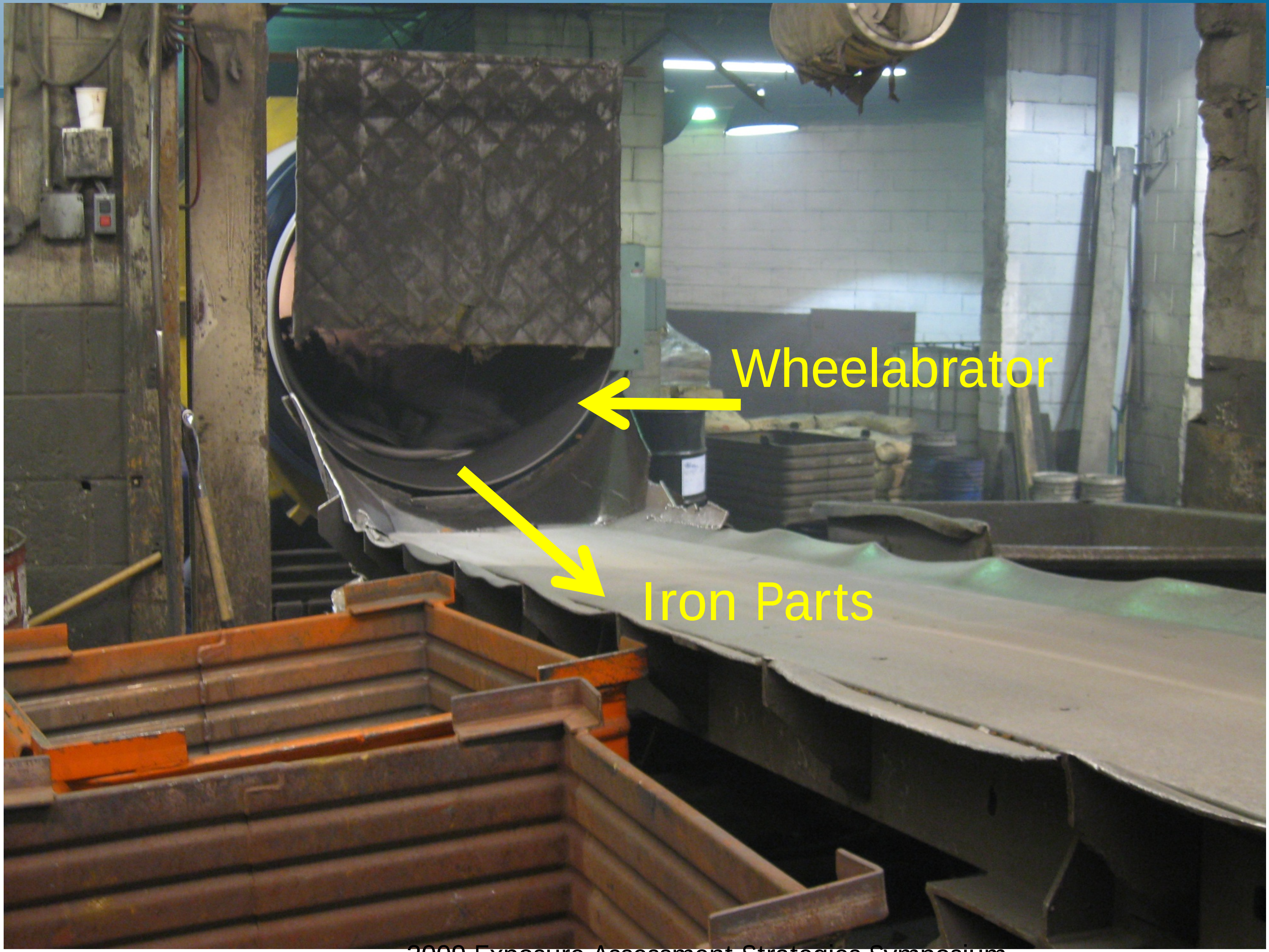
Shaker System

- Mold and iron part are lifted by crane pulley and placed on a vibrating platform ("Shaker"). The iron part and sand get knocked out onto platform.
- The sand/clay get moved away by a shake-out conveyor. The iron parts move to shakeout back end.
- The whole system vibrates heavily.
- Very dusty environment.
- Potential Exposures of Concern = Respirable silica and Noise

Shake-Out Front End - Hot

Moving onto Shaker


Door to
Outside
Parts from BP
Machine


Wheelabrator
Iron Parts

Exposure Category Rating based on Basic Characterization for Respirable dust

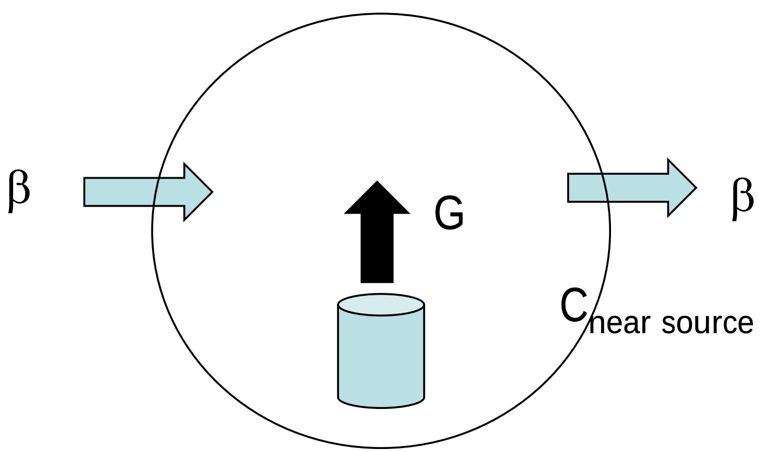
Based on the available knowledge, what is the probability that the 95th percentile of the exposure distribution lies in each of the following categories:

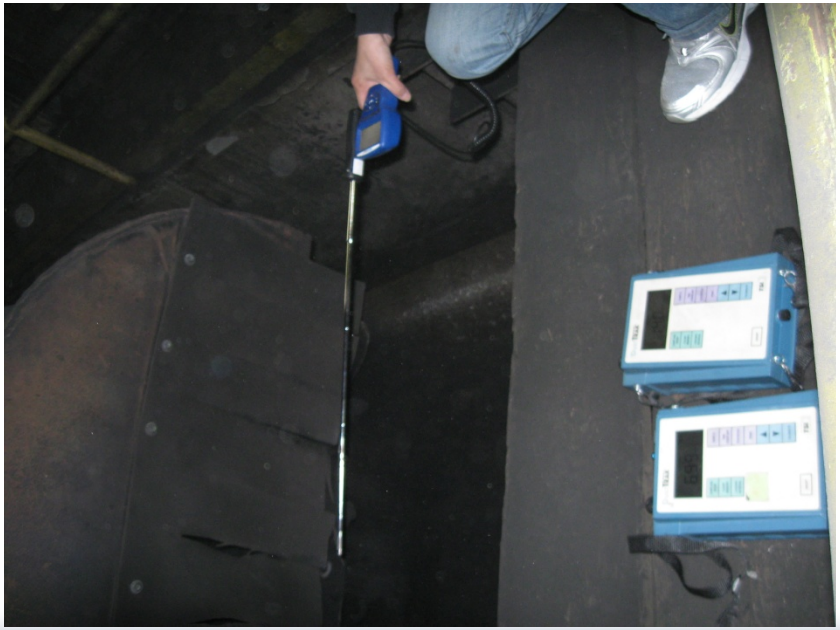
- 95th percentile <0.1 x OEL
- 95th percentile between 0.1 x OEL and 0.5 x OEL
- 95th percentile between 0.5 and 1.0 x OEL
- 95th percentile > OEL

Estimating Generation Rates

- G = $C_{near\text{-}source}$ (mg/m^3) x β (m^3/min)
- Q = Surface area of volume around source (m^2) x Air Velocity (m/s) x 60 (sec/min)

  - $C_{near\text{-}source}$ (mg/m^3)= DustTrak
  - Air Velocity (m/s) = Velocimeter

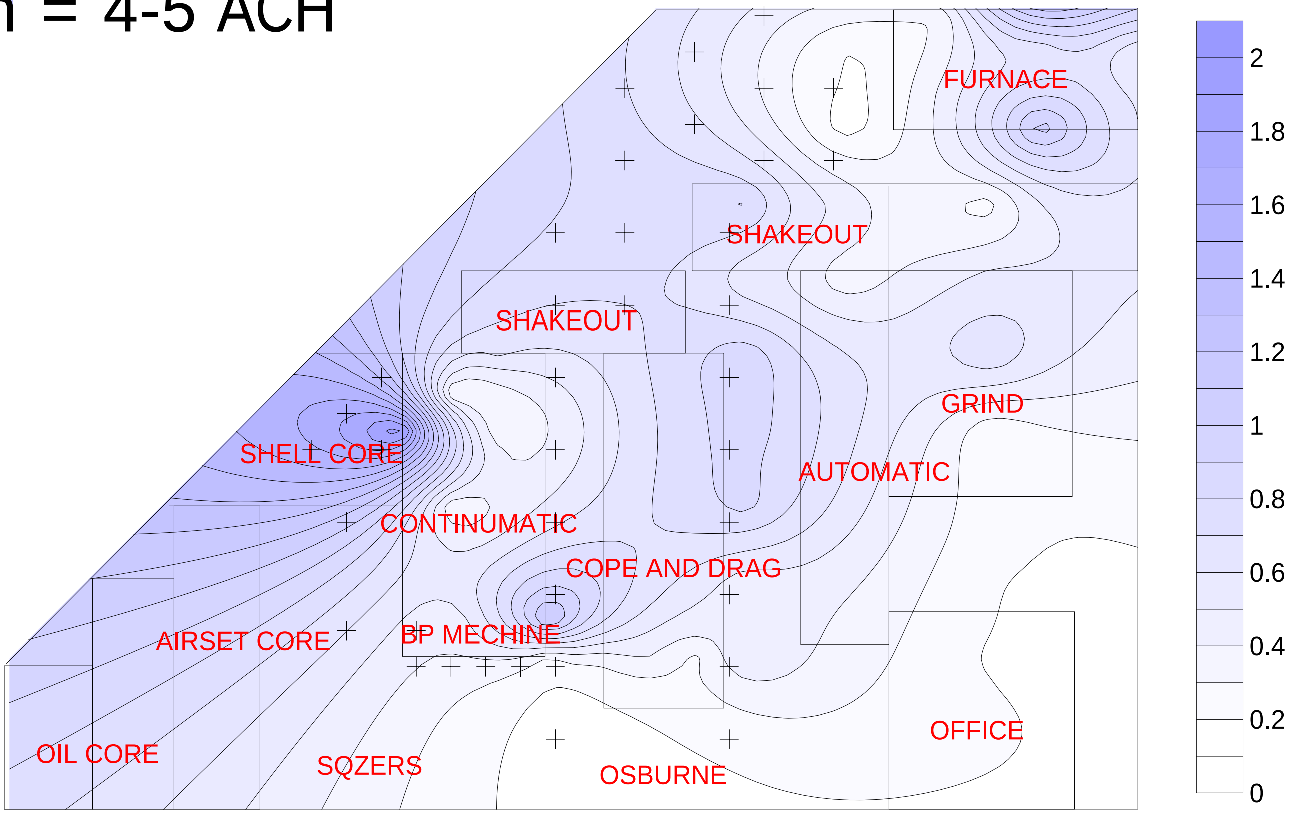




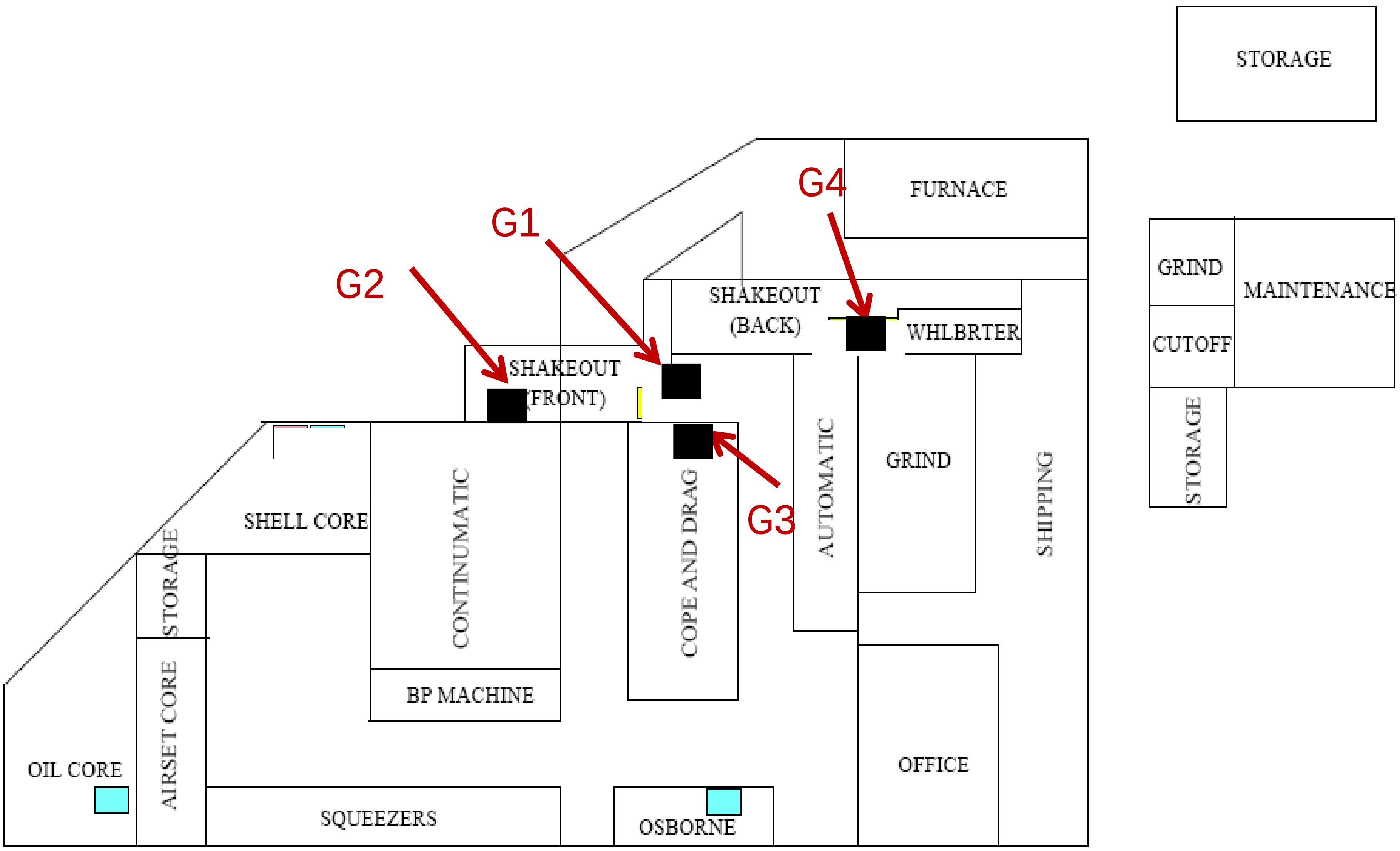
Air Velocity Profiles (meters/second)

Air Velocities in Shake-out areas = 0.3 – 0.6 m/s

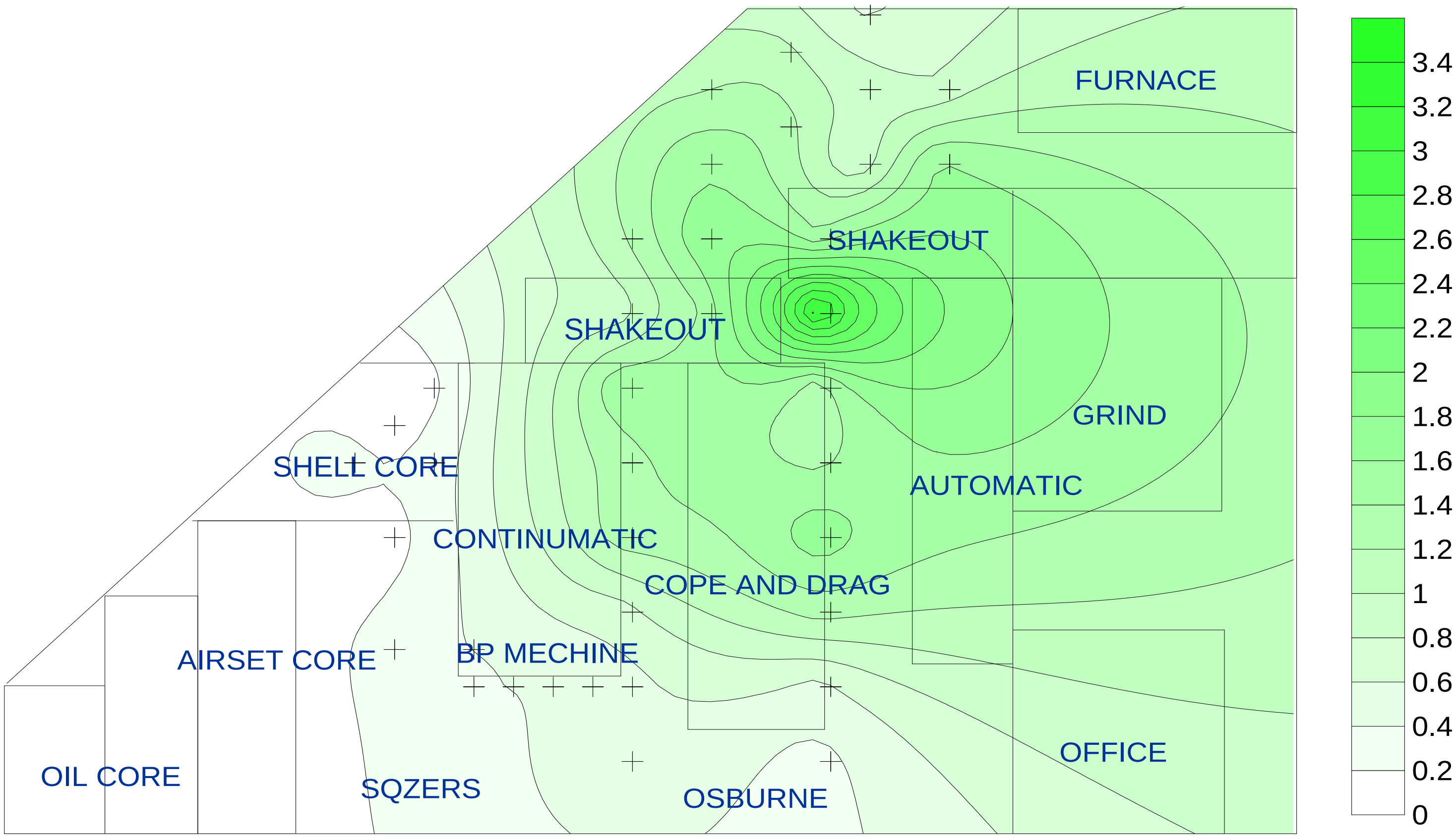
General Ventilation = 4-5 ACH



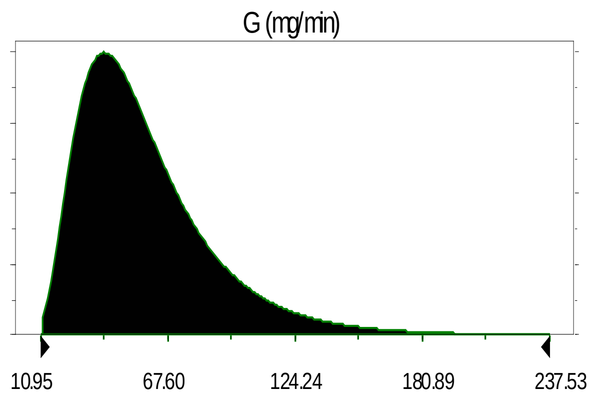
Generation rate measurements

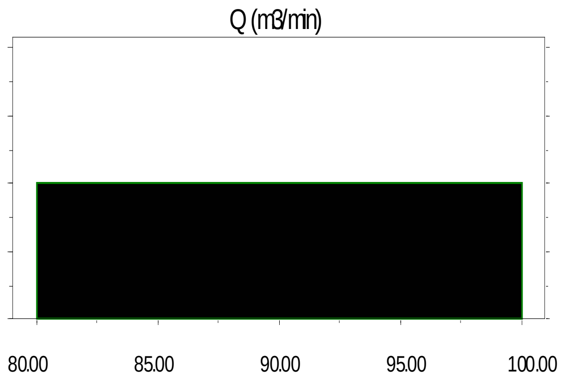


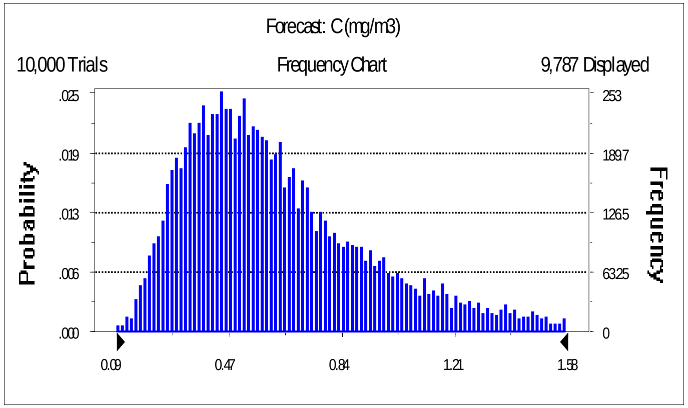
Map of Respirable dust (using DustTrak)



Well Mixed Room Model for respirable dust



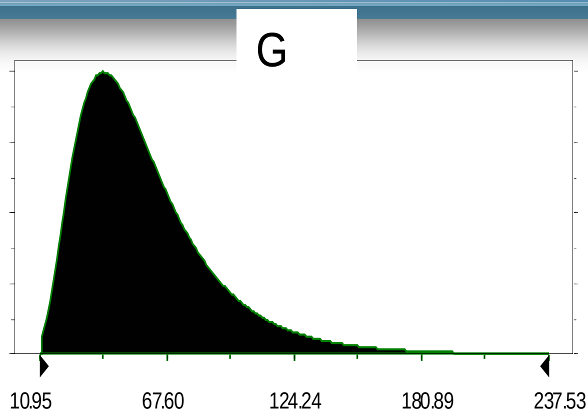


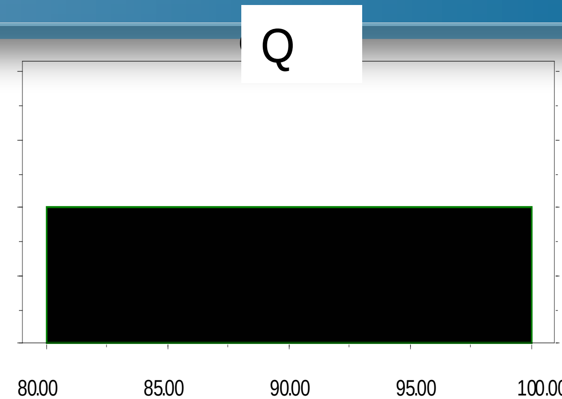


C=G/Q

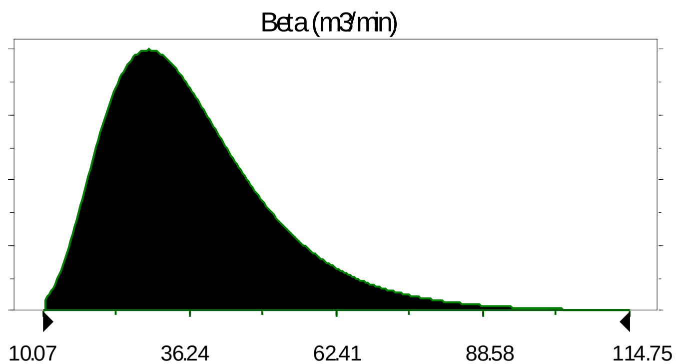
Median = 0.57 mg/ m^3
Mean = 0.65 mg/ m^3
95th Percentile = 1.32 mg/ m^3
GSD = 1.67

Near-Field Far-Field Model for respirable dust



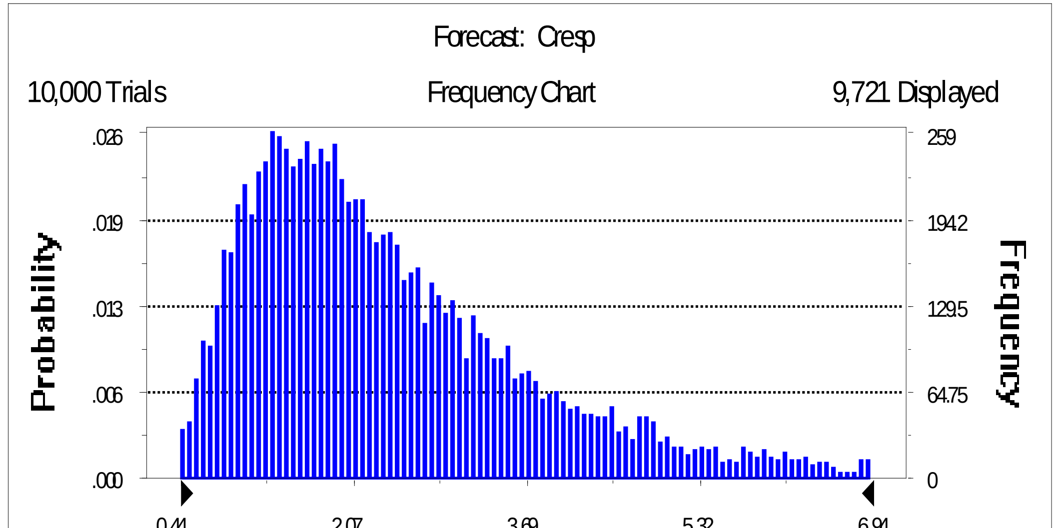


Beta

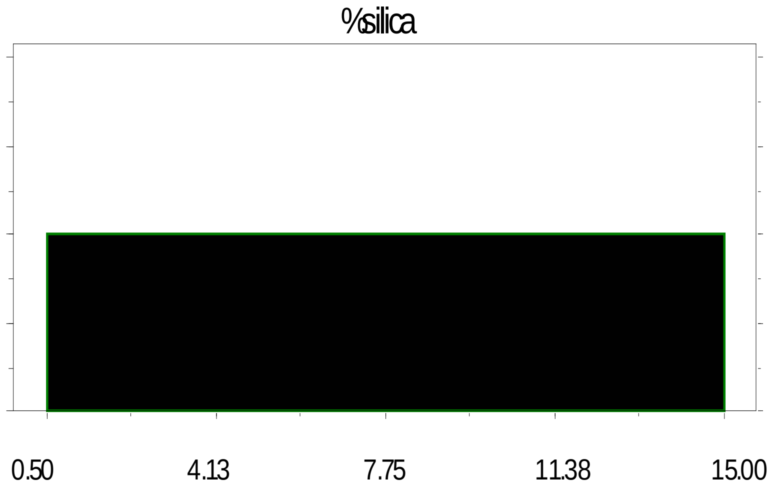


$$C = (G/Q + G/\beta)$$

Median = 2.12 mg/ m^3
Mean = 2.54 mg/ m^3
95th Percentile = 5.73 mg/ m^3
GSD = 1.83



Near-Field Far-Field Model for respirable quartz



$$C = (G/Q + G/\beta)*\%quartz$$

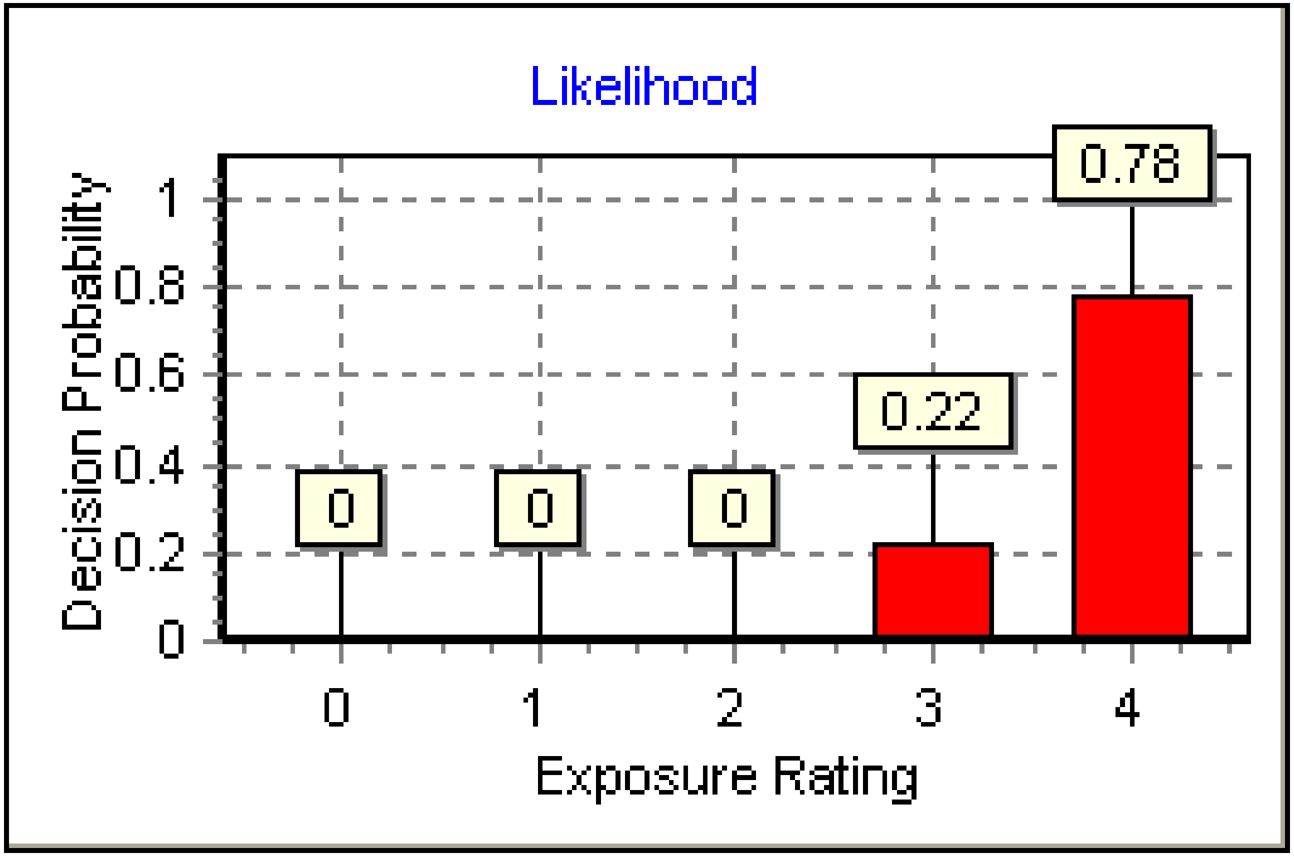
Median = 0.20 mg/ m^3
Mean = 0.25 mg/ m^3
95th Percentile = 0.59 mg/ m^3
GSD = 1.93

Monitoring Data for Silica/Respirable dust

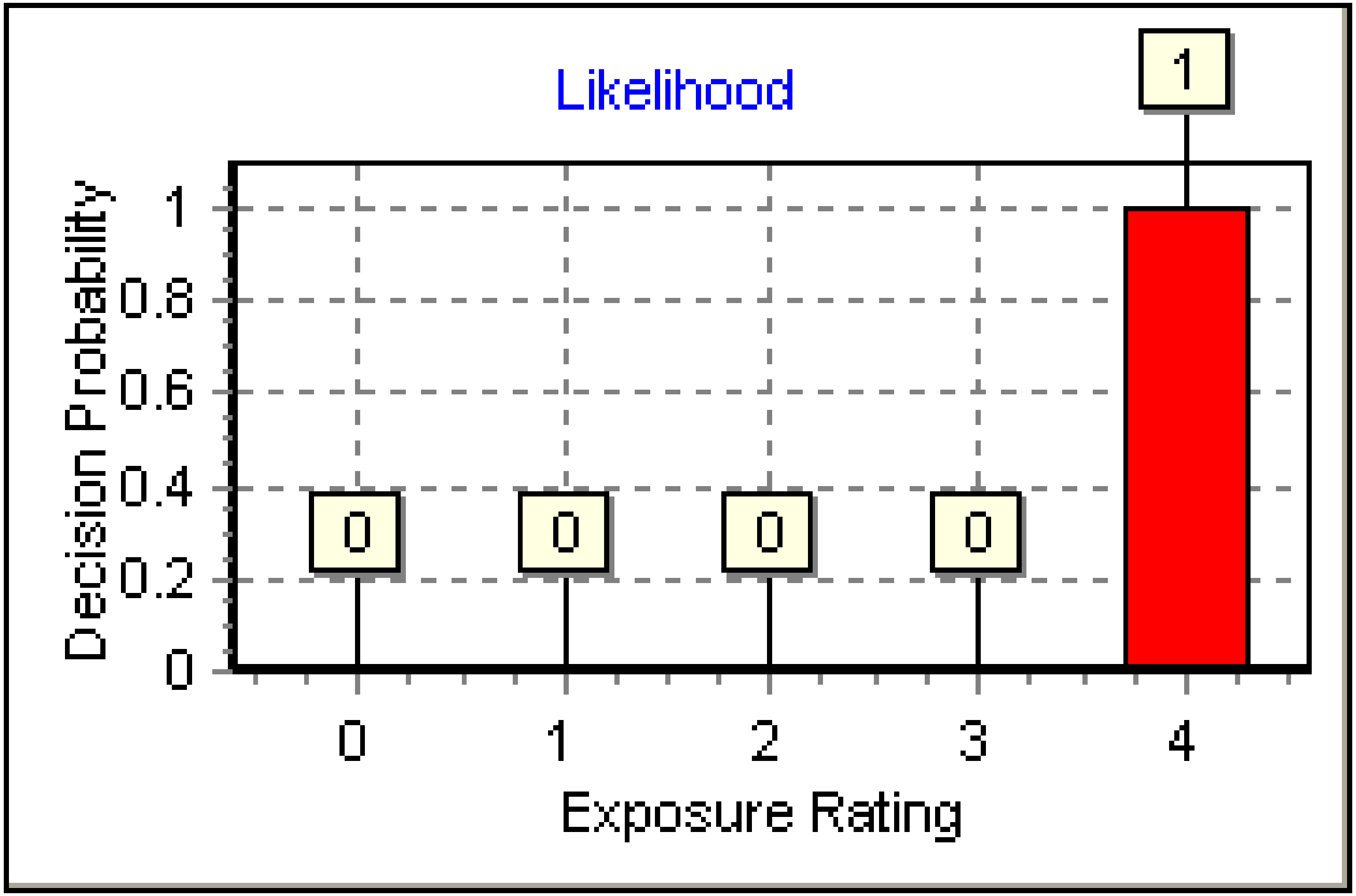
- 8 monitoring data points
- All personal samples from 230 to 470 minutes sampling time.
- Analysis of respirable dust by gravimetry and silica by XRD (NIOSH Method 7500)

Respirable dust (mg/m3)	Quartz (mg/m3)
0.99	0.11
2.6	0.22
1.9	0.29
2.7	0.16
1.5	0.08
2.4	0.24
1.7	0.072
1.1	0.047

Decision based on Respirable dust monitoring data

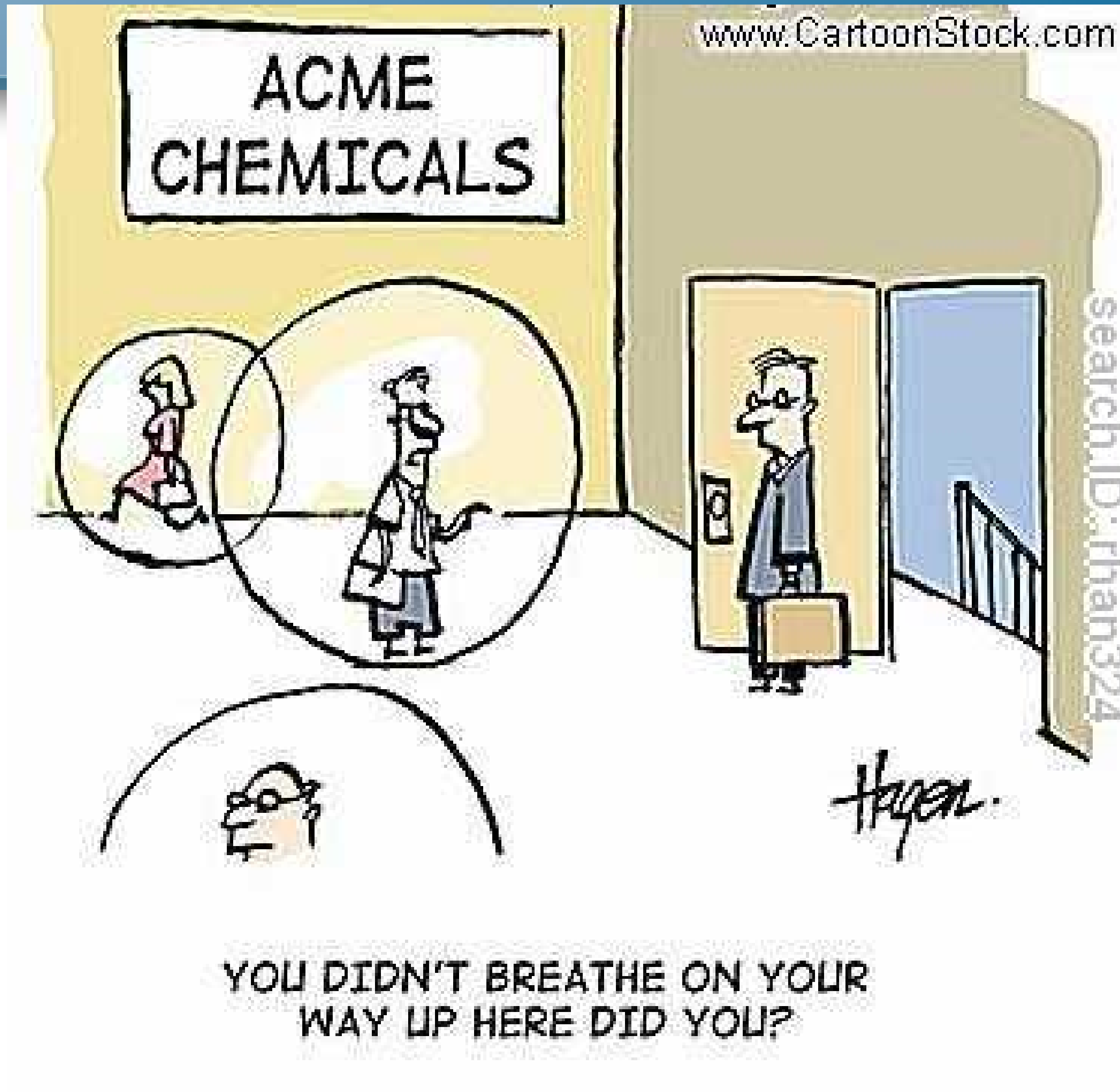


Decision based on Quartz monitoring data



Key Future Issues in Exposure Science

- Increasing the use of probabilistic techniques and uncertainty analysis
- Improving methods of validation
- Considering effects of chemical mixtures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Publication of Assessments!

Most scientists regarded the new streamlined peer-review process as 'quite an improvement.'

Thank You!

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