


Sampling Strategies and Exposure Evaluation in the Smelting Industry



ENSAFE

Multiple Industrial Hygiene issues and challenges in the Smelting Industry



A FEW EXAMPLES

- Chemical hazards include:
 - Metal dusts such as iron and
 - Carcinogens including hexavalent chrome, arsenic, etc.
 - Toxic metals including lead, zinc, and copper
 - Respiratory hazards like alumina dust
 - Skin hazards such as nickel
 - Silica dust or respirable crystalline silica (RCS)
 - Silicosis –potentially causing breathing issues and infections
 - Lung cancer
 - Chronic obstructive pulmonary disease (COPD)
 - Kidney disease
 - Formaldehyde
 - Irritation of the eyes, nose, mouth and throat
 - Asthma-like symptoms
 - Cancers of the nose and throat, as well as leukemia

How does Industrial Health (IH) determine which employees to sample?

A typical smelting plant may employ 400 or more people.

- Start with basic characterization – Safety Data Sheets (SDSs), a QEA, etc.
- Develop Similar Exposure Groups (SEGs)
 - SEGs - groups of workers having the same general exposure profiles because of the similarity and frequency of the tasks or jobs they perform, the materials and processes they work with, and the similar ways they perform these tasks
 - Allows evaluation of a few to represent an entire group
 - Reduces time and expense needed to evaluate exposure potential



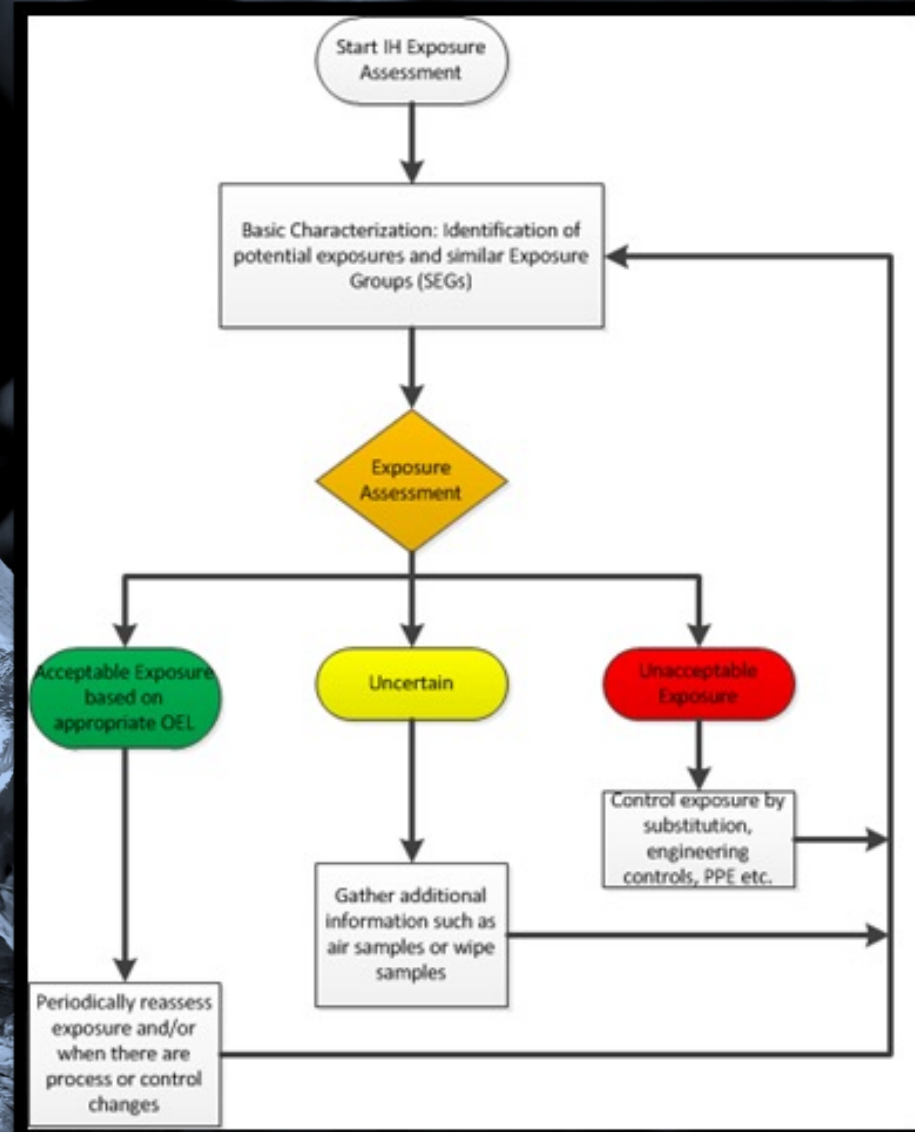
We have our SEGs; how many samples to collect during exposure assessment?

How do we determine if an exposure assessment indicates:

Acceptable exposure

Uncertain exposure

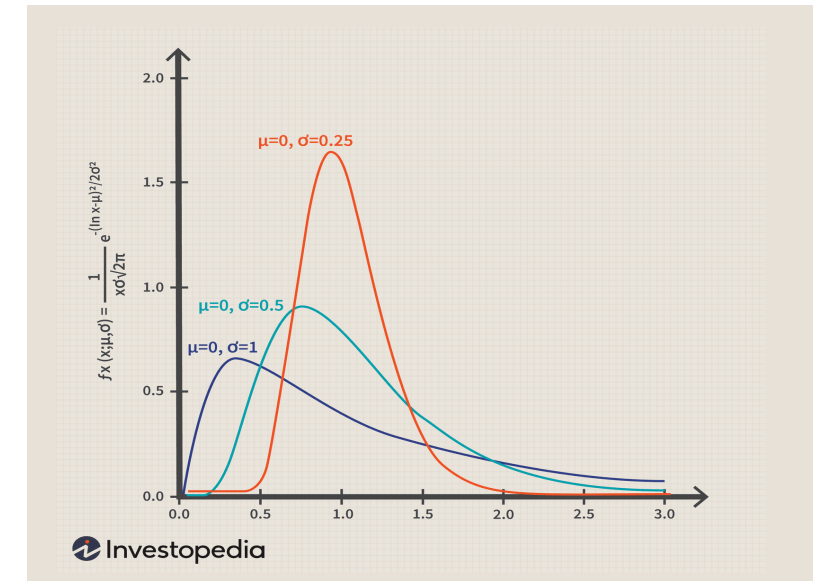
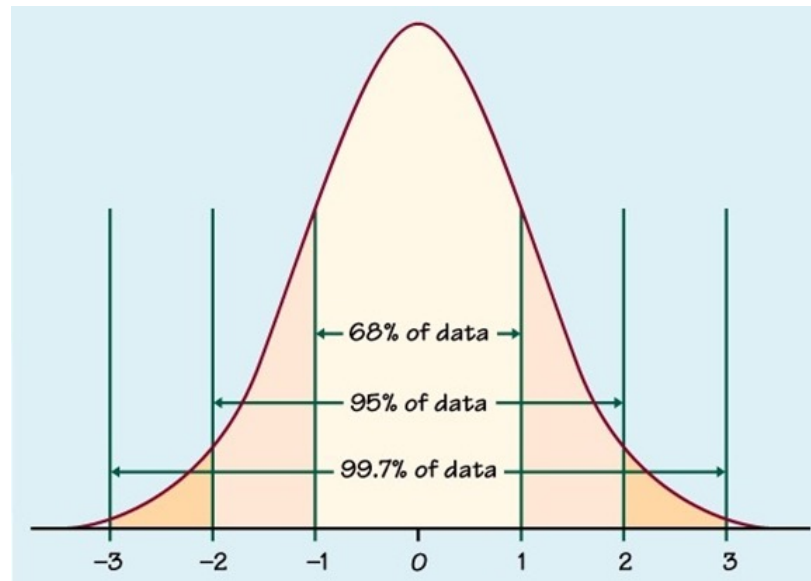
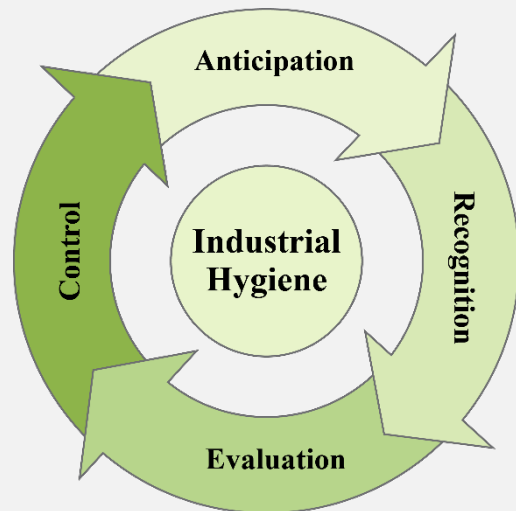
Unacceptable exposure



How many samples are needed for this determination?

Background on IH Data and Assessment

- We see and assume that most data is normally distributed.
- However, IH and most environmental data has been demonstrated to be log-normally distributed.
- This means there is generally a long tail on the high end of the exposure distribution.





Example Smelter Data Set

Sample #	Metal Dust mg/m ³
1	0.8
2	1.5
3	3.7
4	2.2
5	2.6
6	5.3

Classify this exposure:

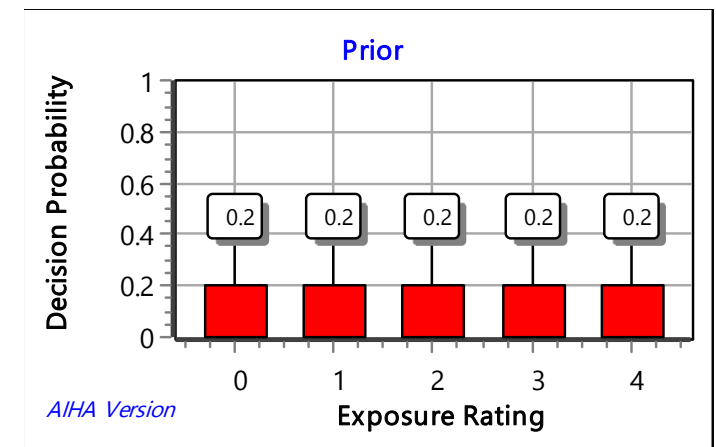
- Acceptable exposure?
- Uncertain exposure?
- Unacceptable exposure?



Data Analysis using IHDA-AIHA

Judgement accuracy is poor if we don't use statistical tools when we have monitoring data.

- A free IH data analysis program available from the American Industrial Hygiene Association
- Test data for log-normal distribution
- Calculates the log-normal mean and standard deviation based on the sampling data inputted.
- Distributes exposure probability across five ranges of the Occupational Exposure Limit (OEL):
 - < 1% OEL
 - 1 - < 10% OEL
 - 10 - < 50% OEL
 - 50 - < 100% OEL
 - > 100% OEL



IHDA-AIHA Output

- Descriptive statistics
- Goodness of fit-test
- Data Plot
- 95% UCL
- Likelihood Plot

Goodness-of-fit Tests:

Fillibens Test:

R = 0.992

critical R = 0.889

Interpretation: the lognormal distribution hypothesis is not rejected.

Substance: Metal dust
OEL = 10 mg/m³

Order Statistics:

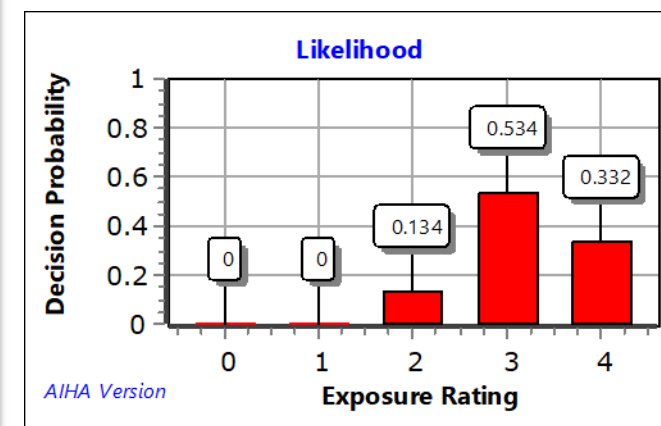
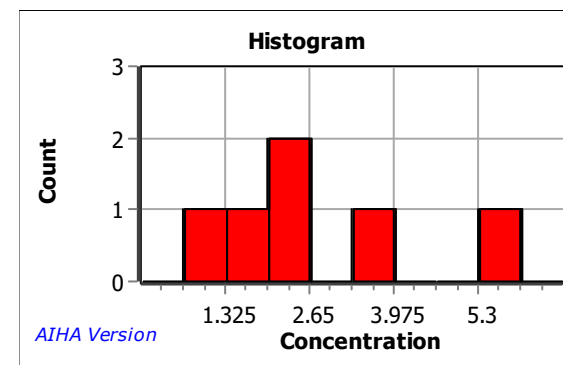
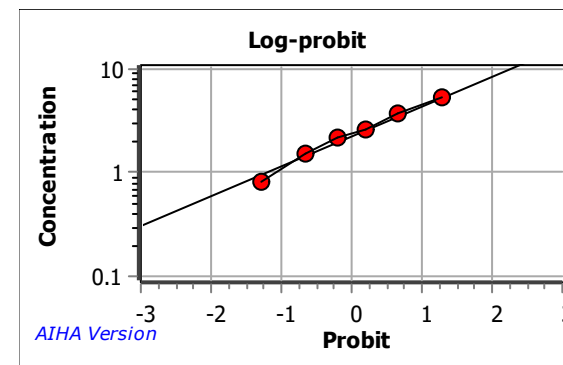
N = 6
Min = 0.8
Max = 5.3
Median = 2.4000

Descriptive Statistics:

Mean = 2.6800
SD = 1.6200
GM = 2.2600
GSD = 1.952

Compliance Statistics (lognormal):

X0.95 =	6.8000	95%LCL = 4.0600	95%UCL = 27.0000
X0.95 =	6.8000	70%UCL = 9.7700 (per EU EN689)	
ExcFrac =	0.013	95%LCL = <0.001	95%UCL = 0.195





Rules of thumb to help with data interpretation



Registered Specialist:
Exposure Decision Analysis

AIHA Registry Programs®

- Given
- $GM = \text{median}$
- $X_{0.95} = GM \times GSD 1.645$
- Rules-of-thumb, or guidelines, can be devised for quickly estimating from limited data the range in which the true 95th percentile might lie:
 - For Low n: If any measurement > OEL then Category 4: 95thile > OEL
 - If one measurement above 50% of OEL, eliminate Categories 0, 1 and 2 (Category 3)
 - Determine median of the data
 - Calculate and compare to OEL:
 - $2 \times \text{median} \sim 95\% \text{ UCL}$
 - $4 \times \text{median} \sim 95\% \text{ UCL}$
 - $6 \times \text{median} \sim 95\% \text{ UCL}$

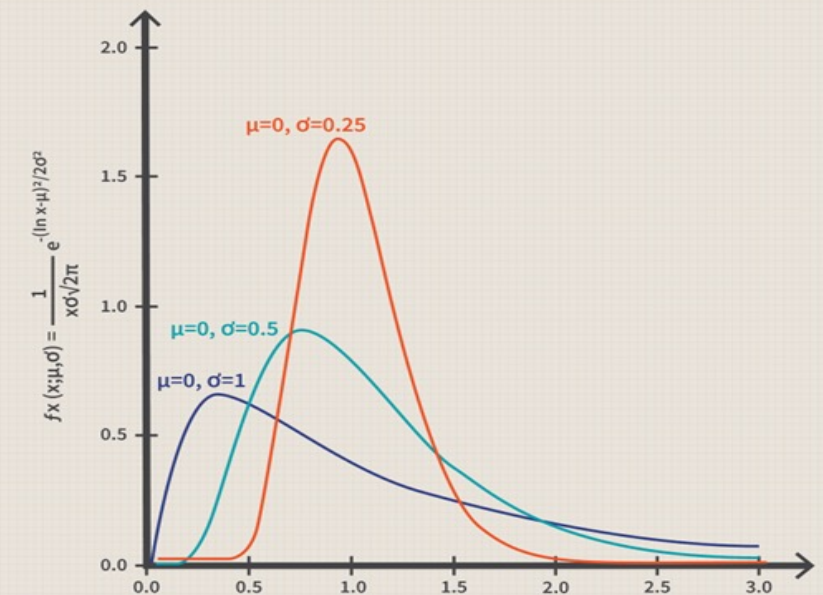
Acceptable Overexposure Potential

- Strive for a 95% UCL with less than a 5% probability of exceeding the OEL.
 - Provides for a less than 5% probability of overexposure.
 - Sometimes a 90% UCL may be acceptable for lower toxicity chemicals.
 - The European Union (EU) has established a threshold of a 70% UCL.
- Compliance vs. Exposure Evaluation Sampling?
 - NIOSH Occupational Exposure Sampling Strategy (77-173) focused on compliance may be updated.
 - Tools identified in this presentation focus on the long-term exposure potential.



How Many Samples to Collect for an Exposure Evaluation

- Each sample is a single snapshot out of up to 365 annual exposures X # shifts worked X employees in the SEG.
- Consider the impact of the longer tail with a log-normal distribution of exposure data.
- The more samples collected:
 - the better the chance of catching the tail
 - it also reduces the geometric standard deviation and data uncertainty
- Balance with resources such as cost, time, and employee availability.
- Generally recommended to evaluate exposure with 5/6 samples collected over time.
- I have used data bases with dozens to hundreds of samples collected of years of time.



Free Tools & References

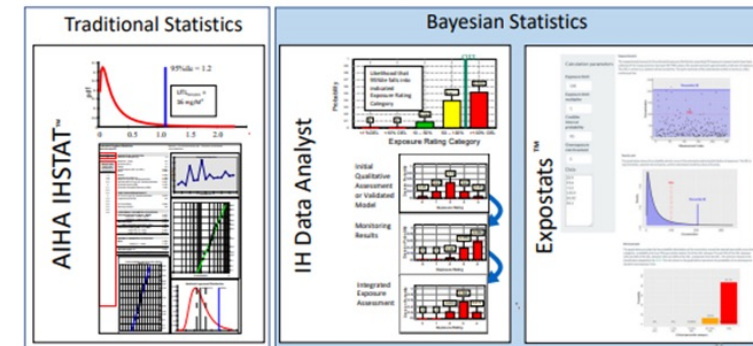
Free IH Statistical Analysis Tools

- IHDA - AIHA - A free version the IH Data Analyst Program (www.easinc.co) designed for EHS students and professionals <https://www.aiha.org/public-resources/consumer-resources/topics-of-interest/ih-apps-tools>
- Expostats Bayesian IH Data Analyst Tool from the University of Montreal <http://expostats.ca/site/en/index.html>
- IHSTAT – An Excel application that calculates various exposure statistics, performs goodness of fit tests, etc.

References

- AIHA – Making Accurate Exposure Risk Decisions Course
- AIHA – A Strategy for Assessing and Managing Occupational Exposures

Use Statistical Tools!!







Thank you!

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