

## IH Data Analyst – Student

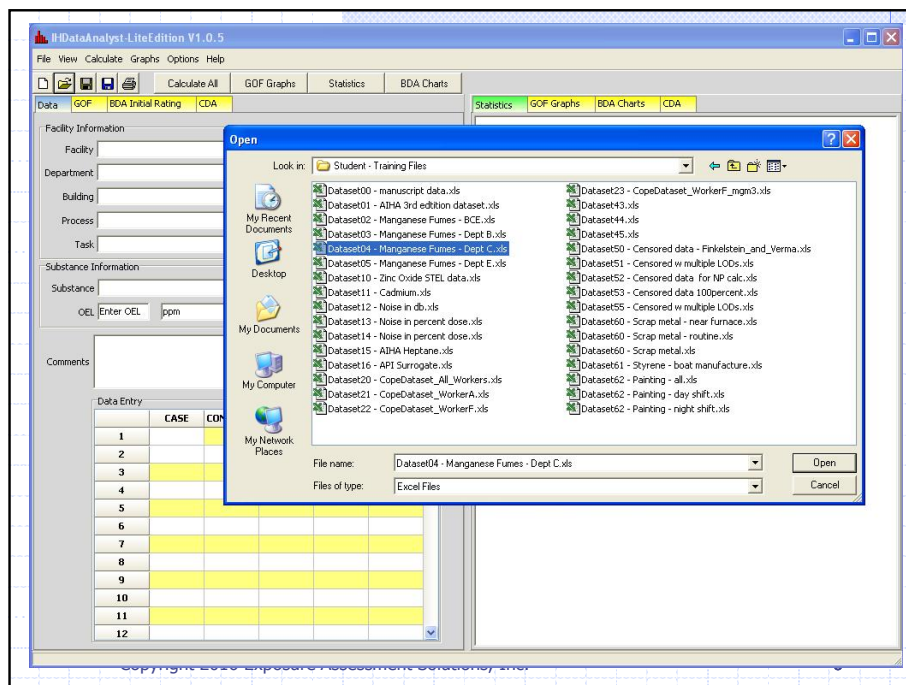
- ◆ Excel spreadsheet compatible:
  - data are saved in the Excel compatible file format (\*.xls)
  - exposure data may be pasted from an Excel spreadsheet
- ◆ **Help File**
- ◆ Order statistics (i.e., non-parametric statistics)
- ◆ Descriptive statistics
- ◆ Compliance statistics
- ◆ Goodness-of-fit:
  - subjective (i.e., log-probit graph)
  - objective (i.e., a statistical test of goodness-of-fit)

## IHDA-LE (cont'd)

- ◆ Limited to 25 measurements.
- ◆ Bayesian Decision Analysis
  - *LiteEdition* does not adjust for censored data (i.e., nondetects)
- ◆ Censored Data Analysis
  - Substitution ( $\text{LOD}/2$ ,  $\text{LOD}/\sqrt{2}$ )
  - LPR and MLE method
- ◆ Graphs and statistical output can be copied and pasted into any word processor.

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IHDataAnalyst-LiteEdition V1.27

File View Calculate Graphs Options Help

Calculate All GOF Graphs Statistics BDA Charts

Data GOF BDA Initial Rating CDA

Facility Information

Facility: ACME Welding

Department: Department C

Building:

Process:

Task:

Substance Information

Substance: manganese fume (as Mn)

OEL: 0.2 mg/m<sup>3</sup>

Comments

- TLV basis - CNS impairment
- PEL - 5 mg/m<sup>3</sup> Ceiling (1972)
- SMAW using medium steel welding wire
- controls: LEV

Data Entry

CASE	CONC	<LOD	DATE	GROUP
1	0.056			Worker E
2	0.067			Worker F
3	0.067			
4	0.302			
5	0.097			
6	0.172			
7				
8				
9				
10				
11				

Statistics GOF Graphs BDA Charts CDA

OEL = 0.2 mg/m<sup>3</sup>

Order Statistics:

N = 6

Min = 0.056

Max = 0.302

Median = 0.092

Descriptive Statistics:

Mean = 0.127

SD = 0.056

GM = 0.104

GSD = 1.930

Compliance Statistics (lognormal):

X0.95 = 0.307 95%LCL = 0.185 95%UCL = 1.190

ExcFrac = 0.160 95%LCL = 0.036 95%UCL = 0.453

Compliance Statistics (non-parametric):

Right click on most objects to show the popup menu.

D:\EAS\_Training\Student - IHDA Files\Dataset04 - Manganese Fumes - Dept C.xls

IHDataAnalyst-LiteEdition V1.27

File View Calculate Graphs Options Help

Calculate All GOF Graphs Statistics BDA Charts

Data GOF BDA Initial Rating CDA

Step 1: Subjective evaluation:

- Is the exposure profile stationary?
- Evaluate trends with the Time Series chart. Are the data trending upwards or downwards? Is the variability increasing or decreasing?
- Does the single lognormal distribution assumption apply?
- Evaluate the log-probit plot.
- Evaluate the histogram (provided n is large).

Step 2: Objective Evaluation:

- Use a formal, goodness-of-fit test to test the hypotheses:  
H<sub>0</sub>: the exposure profile is lognormal  
H<sub>a</sub>: the exposure profile is not lognormal

Objective GOF Test

Graphs

Time Series

Concentration

Probit

Histogram

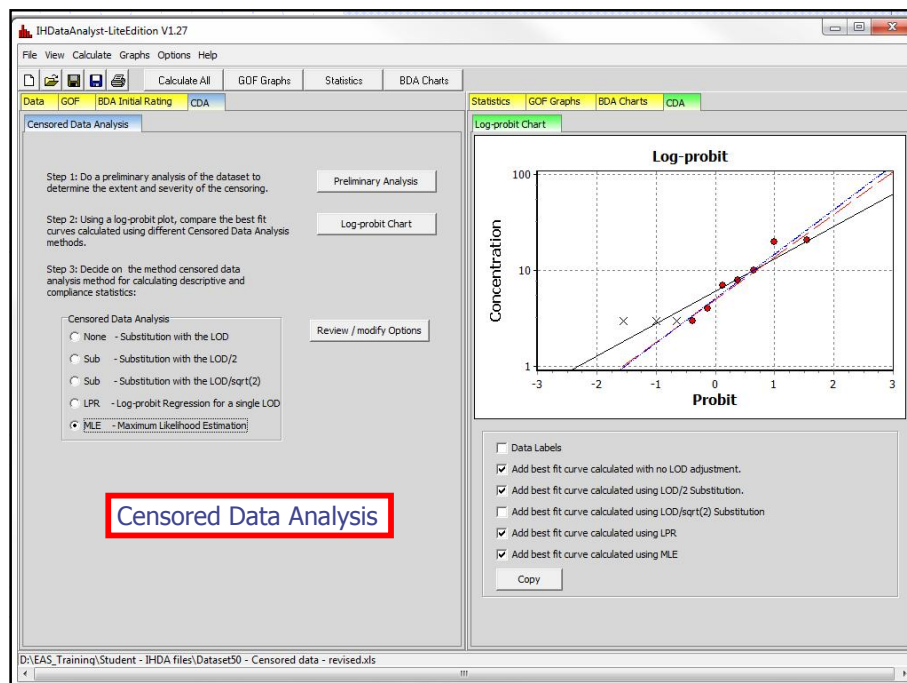
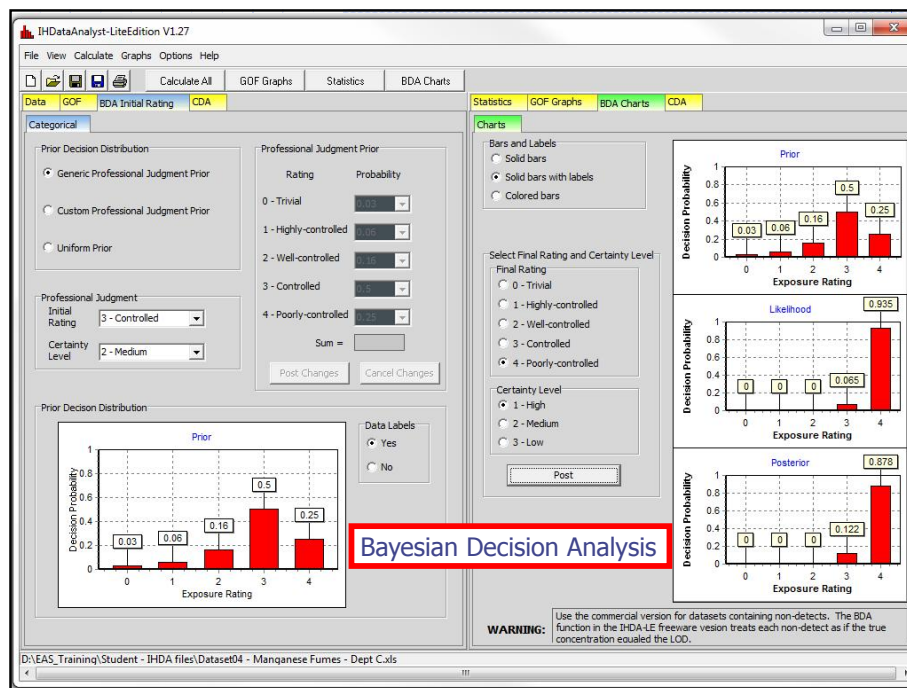
Count

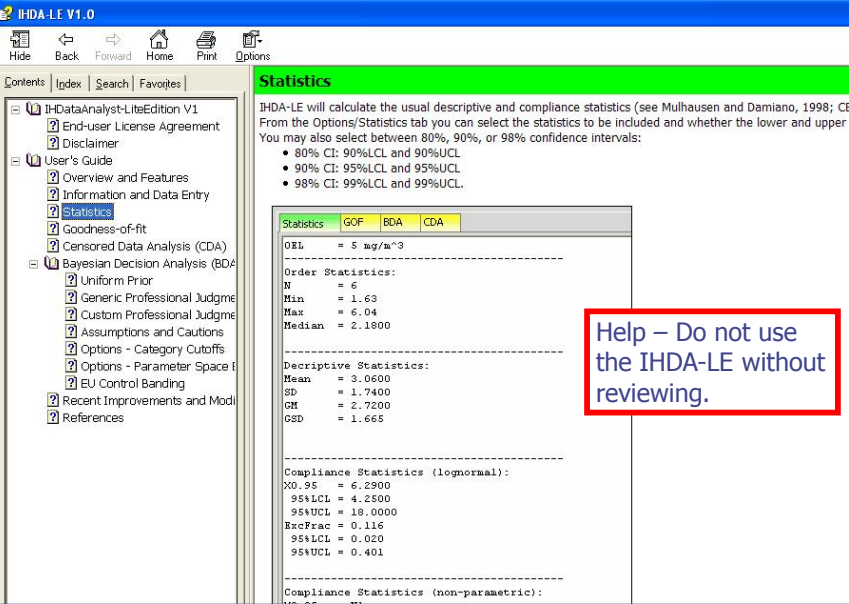
Concentration

Goodness-of-fit

Right click on most objects to show the popup menu.

D:\EAS\_Training\Student - IHDA Files\Dataset04 - Manganese Fumes - Dept C.xls





**Statistics**

IHDA-LE will calculate the usual descriptive and compliance statistics (see Mulhausen and Damiano, 1998; CE). From the Options/Statistics tab you can select the statistics to be included and whether the lower and upper You may also select between 80%, 90%, or 98% confidence intervals:

- 80% CI: 90%LCL and 90%UCL
- 90% CI: 95%LCL and 95%UCL
- 98% CI: 99%LCL and 99%UCL.

Statistics: GOF BDA CDA

OEL = 5 mg/m<sup>3</sup>

Order Statistics:

N = 6  
Min = 1.63  
Max = 6.04  
Median = 2.1800

Descriptive Statistics:

Mean = 3.0600  
SD = 1.7400  
GM = 2.7200  
GSD = 1.665

Compliance Statistics (lognormal):

X0.95 = 6.2900  
95%LCL = 4.2500  
95%UCL = 10.0000  
ExcFrac = 0.116  
95%LCL = 0.020  
95%UCL = 0.401

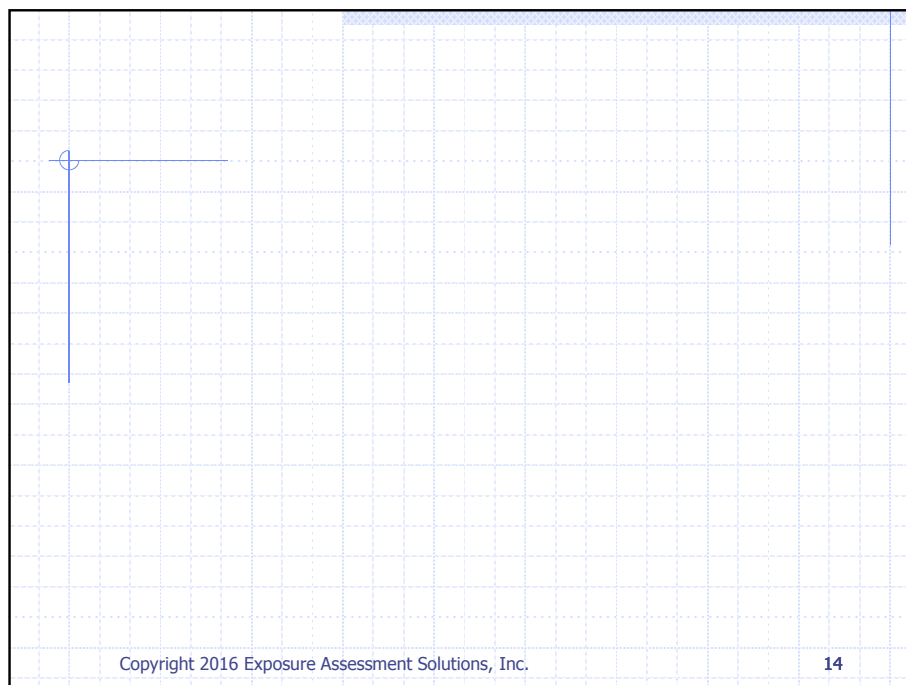
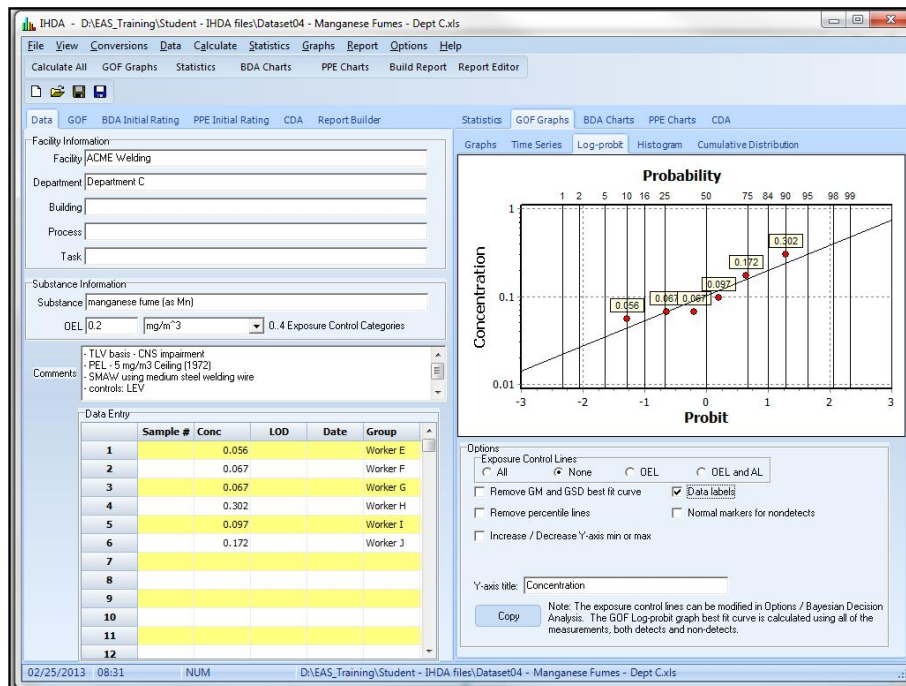
Compliance Statistics (non-parametric):

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## IHDataAnalyst (commercial version)

- ◆ Limited to 2000 measurements.
- ◆ Built-in report generator and editor
- ◆ Bayesian Decision Analysis (BDA) handles censored datasets
- ◆ Censored Data Analysis includes the MLE method
- ◆ Larger, more detailed, and customizable graphs
- ◆ BDA can be used to select PPE for Category 4 exposures
- ◆ Noise exposures can be analyzed using BDA
- ◆ Available from [www.oesh.com](http://www.oesh.com)





## Mixture of SEGs

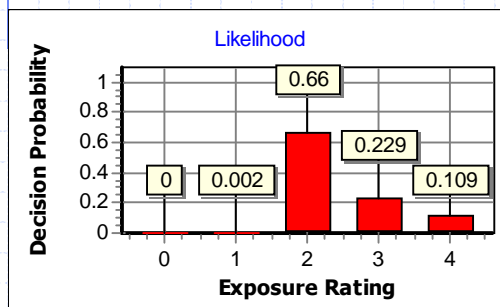
- ◆ A common data analysis error is the combination of different exposure profiles into one SEG.
- ◆ This can result in inflated sample GSDs and 95<sup>th</sup> percentiles, and misleading BDA Decision Charts.

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### ◆ Dataset00

- $x = \{0.20, 0.05, 0.10\}$
- $gm = 0.10, gsd = 2$
- $\hat{x}_{0.95} = 0.31$  90%CI(0.16, 20.2)



Note: max GSD was set at 4.

Profile is most likely inside of Parameter Space.

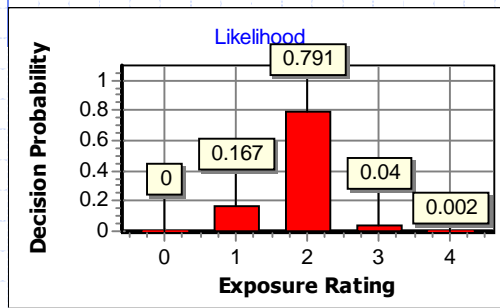
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◆ Dataset00 + two additional measurements

- $x = \{0.20, 0.05, 0.10, 0.001, 0.005\}$
- $gm = 0.022$ ,  **$gsd = 9.14$**
- $\hat{x}_{0.95} = 0.83$  90%CI(0.13, 239)



Note: default max GSD was set at 4.

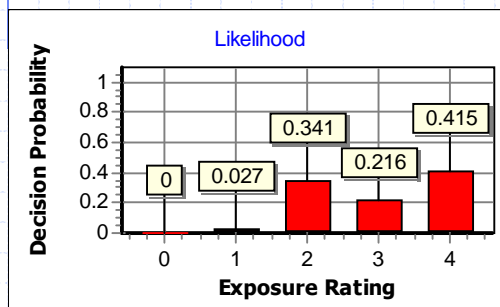
Profile may be outside of Parameter Space.

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◆ Dataset00 + two additional measurements for this SEG

- $x = \{0.20, 0.05, 0.10, 0.001, 0.005\}$
- $gm = 0.022$ ,  **$gsd = 9.14$**
- $\hat{x}_{0.95} = 0.83$  90%CI(0.13, 239)



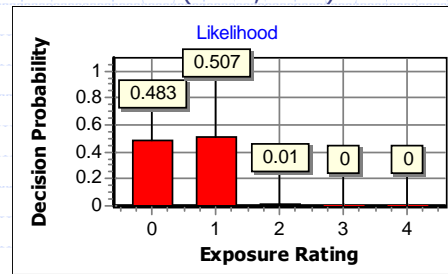
Note: the max GSD was set at 20.

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- ◆ Let's assume that the SEG changed for the better. For example, LEV was installed. The exposure profile is now different and the new data should be analyzed separately

- $X = \{0.001, 0.005\}$
- $gm = 0.002$ ,  **$gsd = 3.12$**
- $\hat{X}_{0.95} = 0.015$  90%CI(0.004, 2E10)



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## Comments

- ◆ Combining data from different exposure scenarios – e.g., a mixture of low and high exposure tasks - can result in extreme and unlikely sample GSDs.
- ◆ This pushes both the compliance statistics and the BDA decision probabilities toward the higher Ratings.
  - Possible solutions:
    - ◆ Collect more information on the determinants of exposure.
    - ◆ Separate the data into more logical groups and analyze separately

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## If I use BDA do I need to calculate the usual descriptive and compliance statistics?

- ◆ Yes, for two reasons:
- ◆ BDA indicates the exposure category that most likely contains the true 95th percentile, but it does not tell you where in the category the 95th percentile is likely to be found. To determine if an exposure profile is likely to be, for example, a low or high Category 3 we must look at the sample 95th percentile.
- ◆ As a rule of thumb, you should suspect that the true exposure profile may be outside of parameter space whenever the sample GSD approaches the upper boundary of 4, and for this comparison you need an estimate of the sample GSD.

## My results change when I change Parameter Space. Which answer is correct?

- ◆ A core assumption of BDA is that the unbounded Parameter Space considered by standard statistics is by definition neither plausible nor physically possible.
- ◆ Because changes in the dimensions of Parameter Space are permitted, there is no fixed, single "answer" or set of BDA charts.
- ◆ However, experience with BDA generally shows that modest changes in the dimensions of Parameter Space lead to the same decision.
- ◆ If the Parameter Space used is plausible for a given exposure scenario then the BDA results are likely to be useful and relevant. If a clearly implausible Parameter Space is used the BDA results will of course be less useful and relevant.

## Do I have to use an informative prior?

- ◆ No. BDA can be applied without an informative prior.
- ◆ In this case, the posterior decision chart will be identical to the likelihood decision chart.
- ◆ When used without an informative prior most of the advantages to BDA still apply: the decision charts for decision making and risk communication are still available, the use of a parameter space and an upper bound on the range of plausible GSDs, and the ability to handle censored datasets (i.e., datasets that contain non-detects).

## Is the final exposure rating always determined using the Posterior Decision Chart?

- ◆ No! Whenever a flat prior is used the Likelihood and Posterior Decision Charts will be identical. In this case, the decision is based on the Likelihood Decision Chart. When you use an informative prior the Posterior chart will always be different from the Likelihood chart.
- ◆ *You have to decide which chart to use.*
- ◆ It is permissible to base your decision upon the Posterior chart whenever the Likelihood and Posterior charts agree on the most likely exposure category (or do not disagree by more than one category) and you believe that the informative prior was reliable.
- ◆ Always document your rationale for using the Likelihood or Posterior decision chart as the basis for your final rating.

## Is the exposure rating conservative if task-based, rather than full-shift, samples are analyzed?

- ◆ Yes, for two reasons.
  - First, the variability of a set of short-term samples is generally greater than the variability of a set of corresponding full-shift samples. This will result in a tendency towards larger decision probabilities for the higher exposure categories.
  - Second, task samples typically do not have periods of known low or zero exposure factored into the concentration calculations. If the remainder of the shift involves zero (or near zero) exposure the task samples will overestimate the full-shift, TWA exposures. This also results in a bias towards the higher categories.
- ◆ Task-based sampling can be advantageous in that the high exposure tasks and related determinates of exposure are more readily identified. In principle, a SEG is unlikely to be a true Category 4 if all of the tasks are rated Category 3 and below.

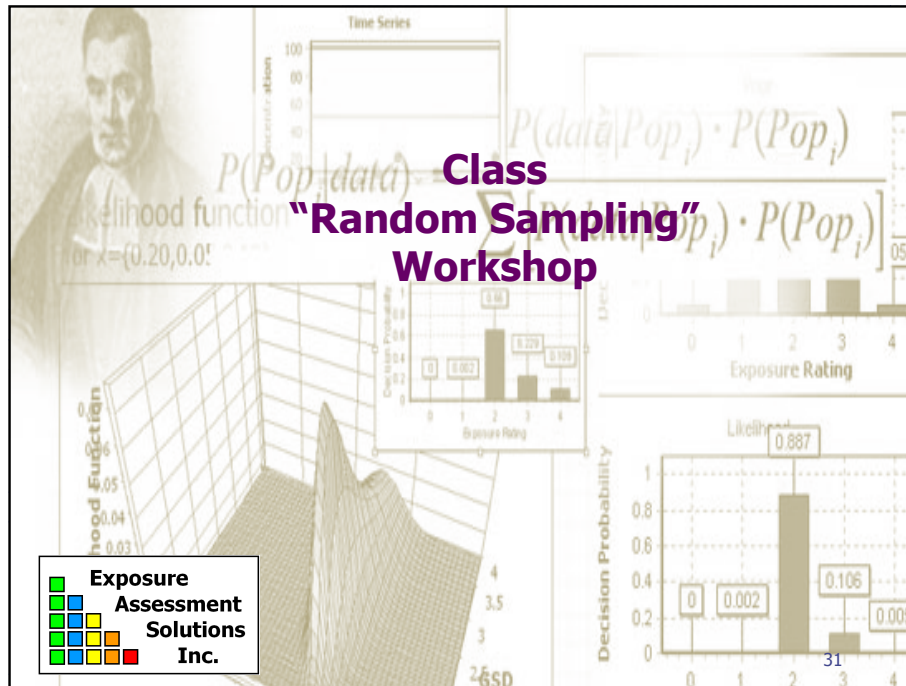
## Can BDA be used when the dataset contains non-detects? Does BDA modify the non-detects by dividing by 2 or $\sqrt{2}$ ?

- ◆ BDA is powered by the same equations that are used in one of the better censored data analysis methods: the Maximum Likelihood Estimation (MLE) method.
- ◆ As a result, it can be applied to datasets that contain one or more non-detects. Unlike the MLE or other methods, it can be applied to datasets where 100% of the measurements are non-detects.
- ◆ BDA does not require the modification of the non-detects by dividing by 2 or any other number.



### How much Category 4 decision probability is “too much”?

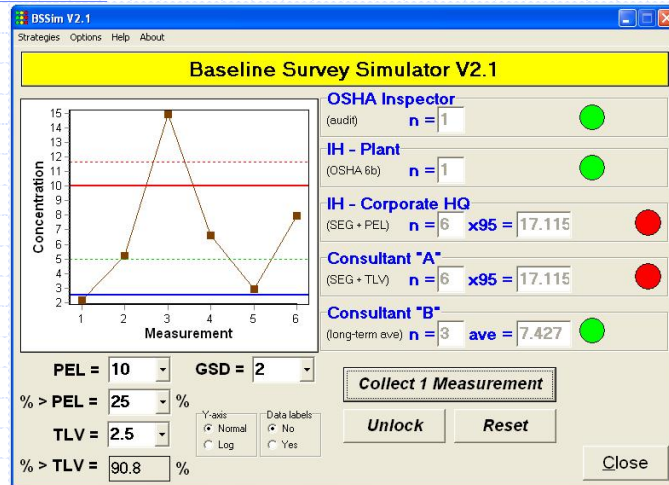
- ◆ What is considered acceptable or tolerable can vary with company, substance toxicity, exposure scenario, the presence and reliability of local controls, the use of protective equipment, and the presence or absence of an exposure surveillance program. As a rule of thumb, for baseline and surveillance surveys one would prefer to see no more than 0.2 or 0.25 for category 4. For a long running process and a mature exposure assessment and management program, where the controls and work practices have been continually improved, the goal should be no more than 0.05 or 0.1.



## Class "Random Sampling" Workshop

- ◆ I. Introduction to the Baseline Survey Simulator V2.1
- ◆ II. Analysis of randomly generated exposure data

## I. Baseline Survey Simulator



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## Observations

- ◆ Different strategies can lead to different decisions.
- ◆ Selection and interpretation of the OEL affects the decision.
- ◆ Poorly controlled work environments:
  - the simple inspector and OSHA 6(b) strategies lack power to reliably detect
  - AIHA strategy will reliably detect

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## II. Analysis of "Random" Exposure Data

- ◆ Divide into groups and assign roles
- ◆ Collect random exposure data
- ◆ Calculate statistics (when required) and BDA Decision Charts
- ◆ Interpret the results
- ◆ Reach a decision:
  - The exposure profile is acceptable
  - The exposure profile is unacceptable

## Divide into Groups and Review Roles

- ◆ OSHA inspector
  - ◆ Plant IH
  - ◆ Corporate IH
  - ◆ Consultant A
  - ◆ Consultant B
- ◆ *Each* group will have at least one "BDA person" who will use BDA to evaluate the data and suggest a "BDA-based interpretation."

## OSHA Inspector - audit strategy + the OSHA limit (PEL; Permissible Exposure Limit)

- ◆ Data Collection
  - Select an exposure group.
  - Identify 1 or more "representative" employees.
  - Collect 1 measurement from the representative employee(s).
- ◆ Data Analysis
  - No statistical analysis is required.
- ◆ Data Interpretation
  - The exposure profile is acceptable if every  $C \leq OEL$ .
  - The exposure profile is unacceptable whenever  $C > OEL$ .
    - ◆ Issue a citation (ignore SAE).
    - ◆ Require the employer to investigate and take appropriate action.

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## Plant IH - OSHA-NIOSH 1977 Strategy + the OSHA limit (PEL; Permissible Exposure Limit)

- ◆ Data Collection
  - Select an exposure group.
  - Identify 1 or more "representative" employees.
  - Collect 1 measurement from each employee.
- ◆ Data Analysis
  - No statistical analysis is required.
- ◆ Data Interpretation
  - The exposure profile is acceptable when the initial  $C < \text{Action Limit (AL)}$ .
  - The exposure profile is unacceptable whenever any  $C > OEL$ .
    - ◆ Investigate and take appropriate action.
  - If  $AL \leq \text{initial } C \leq OEL$ , collect additional measurements until ...
    - ◆ two consecutive measurements are  $< AL$  (and conclude that the exposure profile is acceptable), or
    - ◆ any  $C > OEL$  (and conclude that the exposure profile is unacceptable).

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## Corporate IH - AIHA Baseline Strategy + PEL

- ◆ Data Collection
  - Select a "similar exposure group" (SEG).
  - For a baseline survey, randomly select 6 or more workers (6 to 10 is recommended).
  - Collect 1 measurement from each worker.
- ◆ Data Analysis
  - Calculate the sample 95th percentile ( $X_{0.95}$ ) and its 95%UCL.
- ◆ Data Interpretation
  - The exposure profile is acceptable if the sample  $X_{0.95} < \text{OEL}$ . Reassess to confirm.
  - If the 95%UCL  $< \text{OEL}$ , the work environment is acceptable (with high confidence). Reassess to confirm.
  - The exposure profile is unacceptable when  $X_{0.95} > \text{OEL}$ .
    - ◆ Investigate and take appropriate action.

## Consultant A - AIHA Baseline Strategy + TLV

- ◆ Data Collection
  - Select a "similar exposure group" (SEG).
  - For a baseline survey, randomly select 6 or more workers (6 to 10 is recommended).
  - Collect 1 measurement from each worker.
- ◆ Data Analysis
  - Calculate the sample 95th percentile ( $X_{0.95}$ ) and its 95%UCL.
- ◆ Data Interpretation
  - The exposure profile is acceptable if the sample  $X_{0.95} < \text{OEL}$ . Reassess to confirm.
  - If the 95%UCL  $< \text{OEL}$ , the work environment is acceptable (with high confidence). Reassess to confirm.
  - The exposure profile is unacceptable when  $X_{0.95} > \text{OEL}$ .
    - ◆ Investigate and take appropriate action.



## Consultant B - calculate a group mean + PEL

- ◆ Data Collection
  - Select a "similar exposure group" (SEG).
  - Randomly select 3 or more workers.
  - Collect 1 measurement from each worker.
- ◆ Data Analysis
  - Calculate the group mean exposure (and its 95%UCL).
- ◆ Data Interpretation
  - The exposure profile is acceptable if the sample mean is  $\leq$  PEL.
  - The exposure profile is acceptable (with high confidence) if the  $95\%UCL \leq$  PEL.
  - The exposure profile is unacceptable when the sample mean is  $>$  PEL.
    - ◆ Investigate and take appropriate action.

## Collect, Analyze, and Interpret Exposure Data

- ◆ We will assume that ...
  - the data is reasonably lognormal
  - appropriate sampling methods were used
  - workers were selected in a random fashion
  - The samples were sent to a certified laboratory.
- ◆ As data are collected ...
  - enter into IHStats.xls or IHDataAnalyst-*Student*
  - calculate descriptive and inferential statistics
  - Generate BDA Decision Charts

**Score** (record the decision - (A)cceptable or (U)nacceptable) – and the Number of measurements needed to reach a decision)

	1	2	3	4	5
OSHA Inspector					
Plant IH					
Corporate IH					
Consultant A					
Consultant B					

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### Class observations

- ◆ ?
- ◆ ?
- ◆ ?
- ◆ ?
- ◆ ?

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