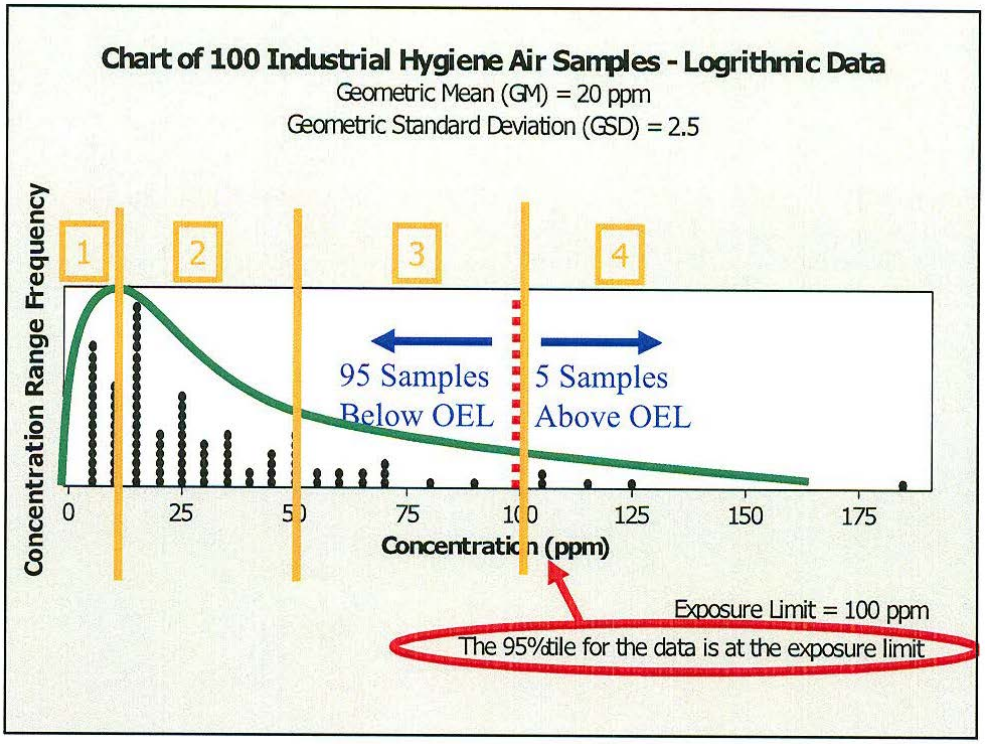
Exposure Assessment

Chapter 9, 3rd Edition OEEC&M (Chapter 6 of 2nd Edition)

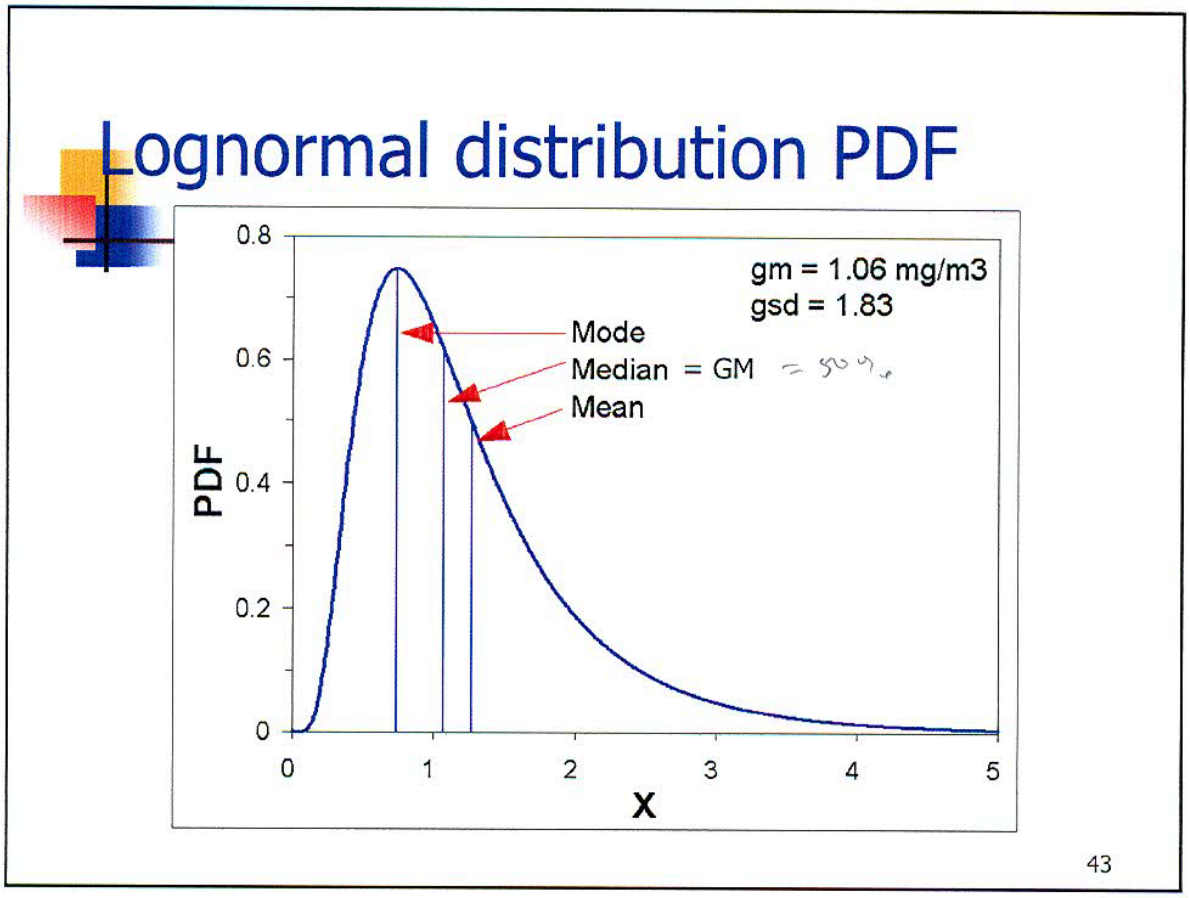
- IH effectiveness goal is to ensure that no worker has unacceptable exposures
- Often there is too little data on which to base judgment
- How often is it acceptable to be wrong?
  - If 5%, then use 95% confidence intervals.
- What are the consequences of the overexposure?
  - Loss of life, premature death, illness, then 0%
- Control Banding
  - An approach to reduce risk with few samples to base our judgment
  - Using the limited data, estimate the exposure category which is linked with recommended controls or action to be taken

AIHA Control Banding

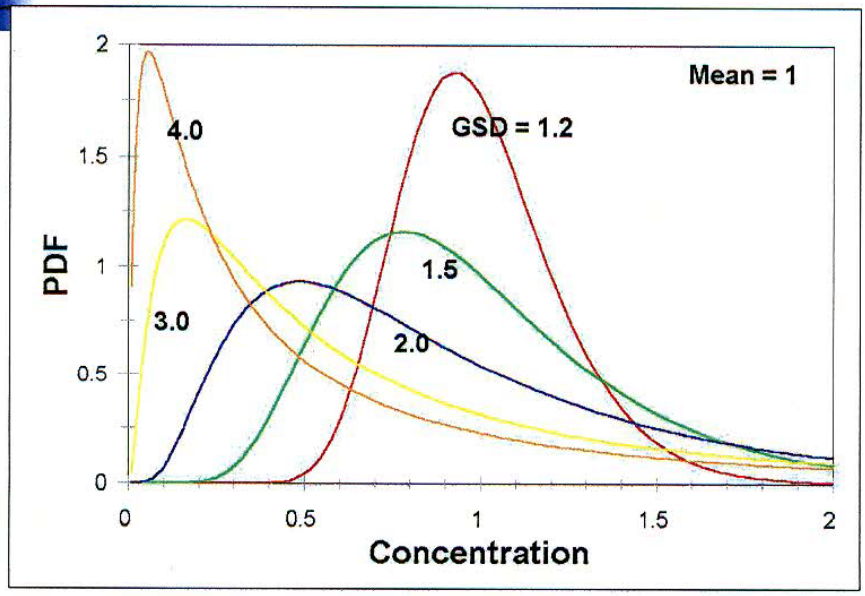
Exposure Category (%OEL)	Recommended Actions or Controls
0 (<1% of OEL)	No action
1 (<10% of OEL)	General hazard communication
2 (10<50% of OEL)	Add chemical and process specific hazard communication
3 (50-100% of OEL)	Add medical surveillance, work practices, monitoring
4 (>100% of OEL)	Add PPE, respirators, engineering controls, work practice controls
Multiples of OEL	Immediate action, prevent access, engineering controls, shut down



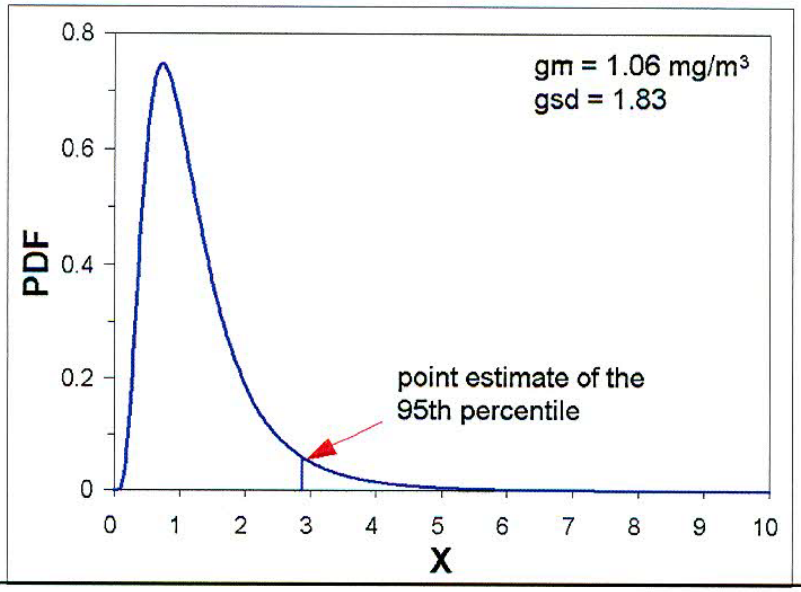
- OSHA calculates the 95% CI for the mean, if LCL > PEL → cite
- If UCL < PEL, compliance, but consider the % of time the standard is exceeded, it may not be acceptable, depending on the agent and the related consequences
- AIHA guidance
    - Ensure that no worker has unacceptable exposure
    - Lognormal distribution
    - Use the 95th percentile of the sample distribution
    - Calculate the 95% CI for the 95th percentile of the sample distribution
    - Use the Upper Tolerance Limit (UTL), 95% UCL of the 95th percentile to assign the exposure category
    - If the UTL or 95% UCL is less than the OEL, then we can say with at least 95% confidence that the 95th percentile is less than the OEL
    - LogNormal2 and IHSTAT
    - Rules of thumb for eyeballing exposure data
        - K values, depend on GSD
            - 2 for GSD of @ 1.5
            - 4 for GSD of @ 2.3
            - 6 for GSD of @ 3.0
    - IH DIG, Industrial Hygiene Data Interpretation Game



Lognormal



Focus on Upper Tail



Upper Percentile (e.g., 95th percentile)

- Concept
  - Calculate the 95% upper confidence interval for the 95th percentile statistic (upper tolerance limit)
- Application
  - 95%UCL can be used to test the following hypotheses:
    - H_o: 95th percentile $\geq$ OEL
    - H_a: 95th percentile < OEL
- Interpretation
  - If the 95%UCL is less than the OEL, then we can say that we are at least 95% confident that the true 95th percentile is less than the OEL

95%UCL for the 95th Percentile

- Procedure:
  - Calculate the gm and gsd
  - Using n, read the UCL K-value from the appropriate table
    - γ = confidence level, e.g., 0.95
    - p = proportion, e.g., 0.95
    - n = sample size
  - Using gm, gsd, and k, calculate the 95%UCL
    - $\overline{y}$ = ln(gm)

$$95\%UCL(\hat{X}_{0.95}) = \exp(\overline{y} + K_{\gamma,p,n} \cdot s_y)$$

True GSD	Multiple of GM (median)
	X_p = 95th percentile
	Z_p = 1.645
1.5	1.95
2.0	3.13
2.5	4.51
3.0	6.09

2
3
4
6

R.O.T. for Estimating the 95th Percentile

1. If n is small (i.e., <6) and one or more meas. > OEL, then decision = Category 4.
2. Estimate median (use it as a surrogate of the calculated sample GM):
   - Sort the data
   - Estimate the median
     - middle value if n is odd
     - average of two middle values if n is even
3. Multiply the median by 2, 4, and 6
   - The results comprise an *approximate* low, middle, and high estimate of $X_{0.95}$.

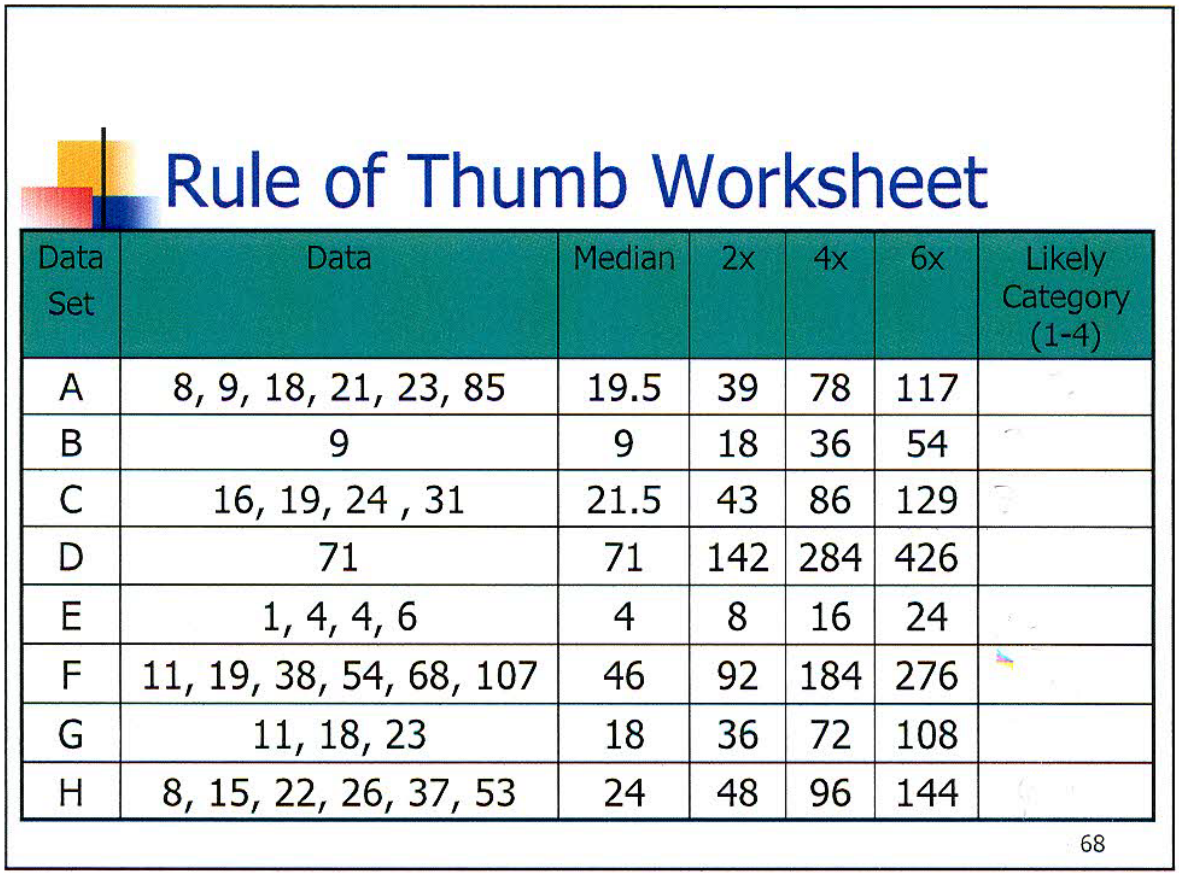
Rule-of-thumb Workshop (assume OEL=100)

A. X = {18, 85, 8, 9, 23, 21}
B. X = {9}
C. X = {16, 31, 19, 24}
D. X = {71}
E. X = {6, 4, 1, 4}
F. X = {19, 38, 107, 68, 11, 54}
G. X = {18, 23, 11}
H. X = {8, 15, 37, 22, 26, 53}

For each dataset, determine the appropriate Exposure Category – 1, 2, 3, or 4 – using the above Rule-of-thumb.

Rule of Thumb Worksheet

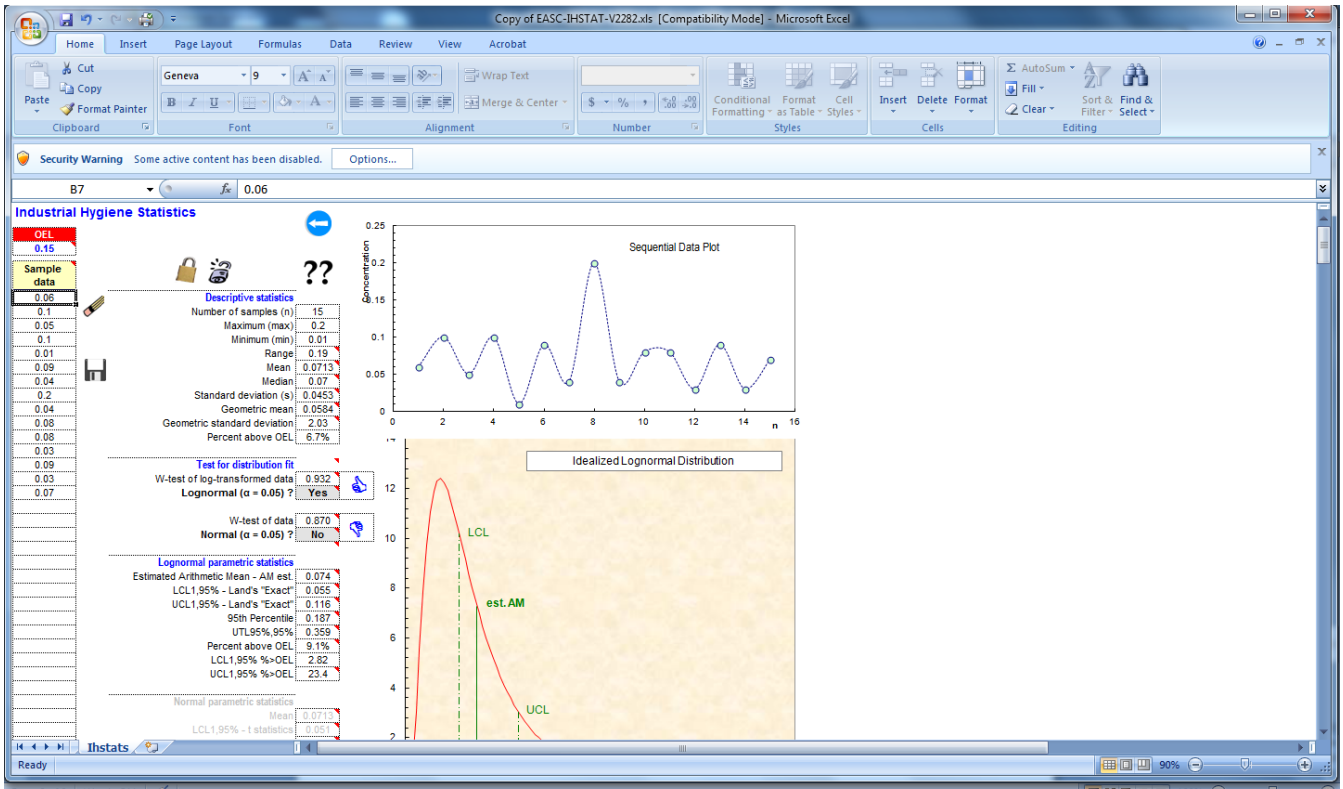
Data Set	Data	Median	2x	4x	6x	Likely Category (1-4)
A	18, 85, 8, 9, 23, 21					
B	9					
C	16, 31, 19, 24					
D	71					
E	6, 4, 1, 4					
F	19, 38, 107, 68, 11, 54					
G	18, 23, 11					
H	8, 15, 37, 22, 26, 53					



Analyze data sets A, C, F and H using IHSTAT

IHSTAT

- Note the **Security Warning**: some active content has been disabled
- Click **Options,** then click the **radial button** to enable content, then click **OK**
- Click on the **IHSTAT** worksheet tab or click on the arrow ⇨
- To display the descriptions of parameters and charts click on **??**
- Go back to **IHSTAT**
- Change the **OEL**
- Insert **sample data**
- View the **Descriptive Statistics**
- What are the values for the:
    - Mean
    - Standard Deviation
    - 95% CI for the mean
    - Upper Tolerance Limit?
- Does the data fit a normal or log-normal distribution?
- What are the Exposure Category and Control Band?


Copy of EASC-IHSTAT-V2282.xls [Compatibility Mode] - Microsoft Excel
Industrial Hygiene Statistics
OEL
0.15
Sample data
Descriptive statistics
Number of samples (n) 15
Maximum (max) 0.2
Minimum (min) 0.01
Range 0.19
Mean 0.0713
Median 0.07
Standard deviation (s) 0.0453
Geometric mean 0.0584
Geometric standard deviation 2.03
Percent above OEL 6.7%
Test for distribution fit
W-test of log-transformed data 0.932
Lognormal (α = 0.05) ? Yes
W-test of data 0.870
Normal (α = 0.05) ? No
Lognormal parametric statistics
Estimated Arithmetic Mean - AM est. 0.074
LCL1,95% - Land's "Exact" 0.055
UCL1,95% - Land's "Exact" 0.116
95th Percentile 0.187
UTL95%,95% 0.359
Percent above OEL 9.1%
LCL1,95% %>OEL 2.82
UCL1,95% %>OEL 23.4
Normal parametric statistics
Sequential Data Plot
Concentration
n
Idealized Lognormal Distribution
LCL
est. AM
UCL
Ihstats
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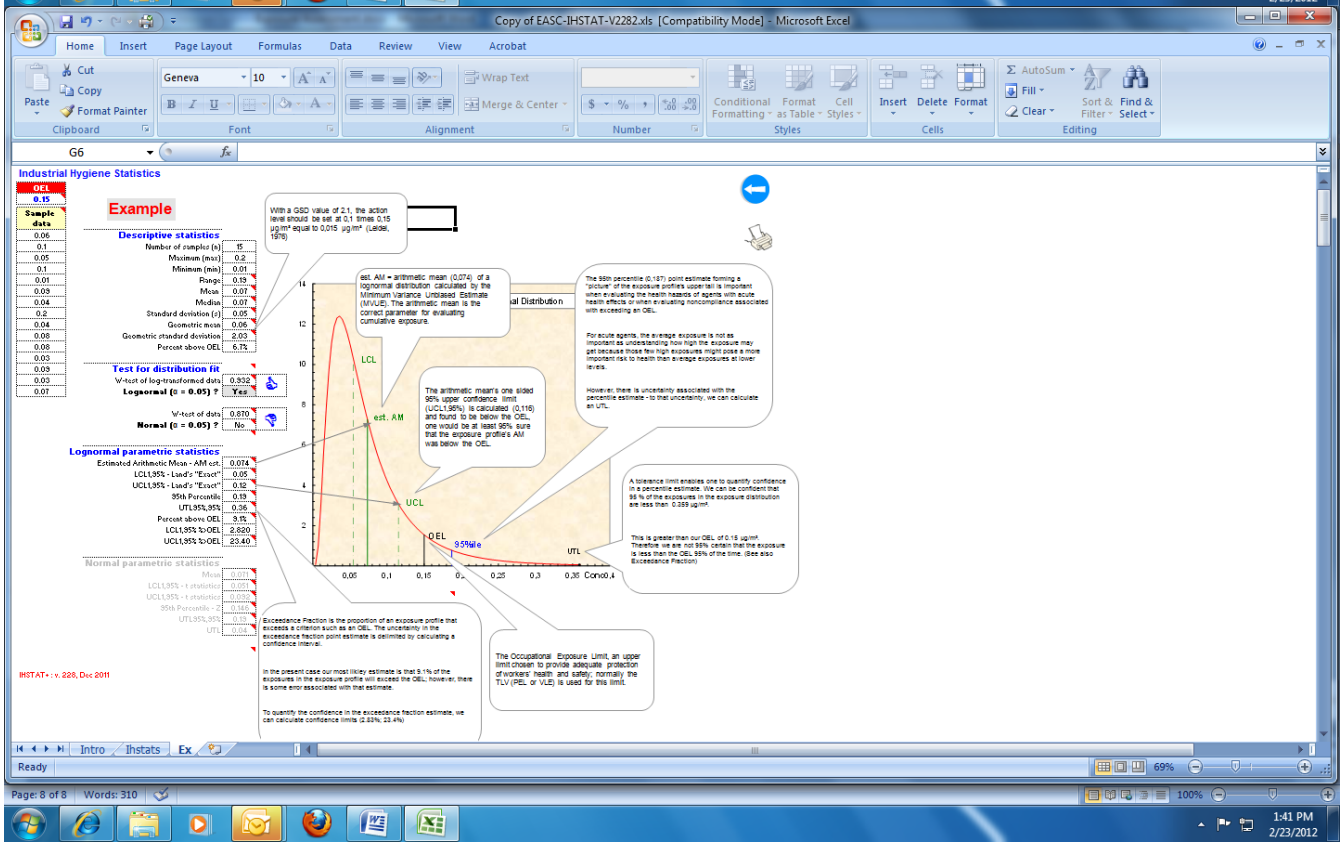
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Industrial Hygiene Statistics
Example
With a GSD value of 2.1, the action level should be set at 0.1 times 0.15 µg/m³ equal to 0.015 µg/m³ (Leidel, 1978)
Descriptive statistics
Test for distribution fit
Lognormal parametric statistics
Normal parametric statistics
est. AM = arithmetic mean (0.074) of a lognormal distribution calculated by the Minimum Variance Unbiased Estimate (MVUE). The arithmetic mean is the correct parameter for evaluating cumulative exposure.
The 95th percentile (0.187) point estimate forming a "picture" of the exposure profile's upper tail is important when evaluating the health hazards of agents with acute health effects or when evaluating noncompliance associated with exceeding an OEL.
For acute agents, the average exposure is not as important as understanding how high the exposure may get because those few high exposures might poke a more important risk to health than average exposures at lower levels.
However, there is uncertainty associated with the percentile estimate - to that uncertainty, we can calculate an UTL.
The arithmetic mean's one sided 95% upper confidence limit (UCL1,95%) is calculated (0.116) and found to be below the OEL, one would be at least 95% sure that the exposure profile's AM was below the OEL.
A tolerance limit enables one to quantify confidence in a percentile estimate. We can be confident that 95 % of the exposures in the exposure distribution are less than 0.359 µg/m³.
This is greater than our OEL of 0.15 µg/m³. Therefore we are not 95% certain that the exposure is less than the OEL 95% of the time. (See also Exceedance Fraction)
LCL
est. AM
UCL
OEL
95%ile
UTL
Exceedance Fraction is the proportion of an exposure profile that exceeds a criterion such as an OEL. The uncertainty in the exceedance fraction point estimate is delimited by calculating a confidence interval.
In the present case our most likley estimate is that 9.1% of the exposures in the exposure profile will exceed the OEL; however, there is some error associated with that estimate.
To quantify the confidence in the exceedance fraction estimate, we can calculate confidence limits (2.83%; 23.4%)
The Occupational Exposure Limit, an upper limit chosen to provide adequate protection of workers' health and safety, normally the TLV (PEL or VLE) is used for this limit.
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