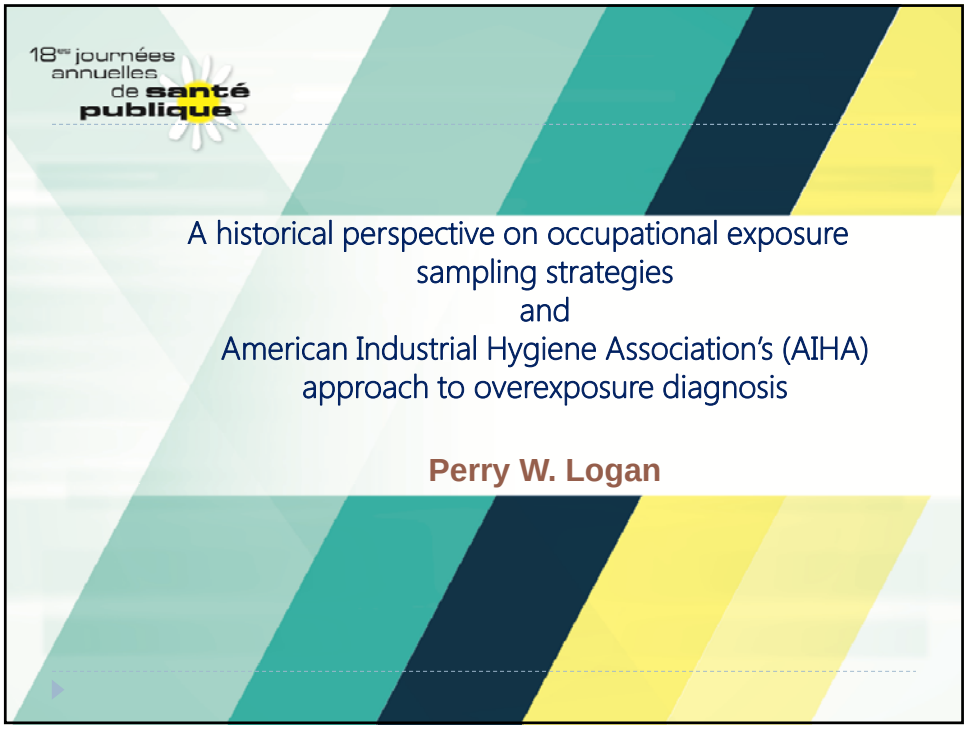
Cette présentation a été effectuée le 26 novembre 2014 au cours de la journée « Les probabilités de dépassement de seuil pour diagnostiquer l'exposition aux contaminants chimiques en milieu de travail » dans le cadre des 18es Journées annuelles de santé publique (JASP 2014). L'ensemble des présentations est disponible sur le site Web des JASP à la section Archives au : http//jasp.inspq.qc.ca.



Acknowledgments

- Dr. Martha Waters, NIOSH
- Dr. Paul Hewett, formally NIOSH (EAS Inc.)
- Members of AIHA Exposure Assessment Strategies Committee

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Discussion Topics

- Brief Review of Exposure Assessment Strategies
- AIHA's Exposure Assessment Strategy
- Top 5 Aspects of a Good Exposure Assessment Strategy

3

Survey Questions

4

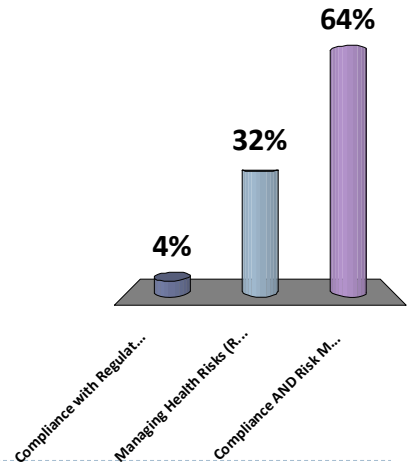
What is most important to you?

1. Compliance with Regulations
2. Managing Health Risks (Risk Management)
3. Compliance AND Risk Management

5

What is most important to you?

A. Compliance with Regulations
B. Managing Health Risks (Risk Management)
C. Compliance AND Risk Management



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Data Interpretation Example

- Employee performs a job 100 times per year
- If you collected personal samples on the employee all 100 times, how many times is it acceptable for exposures to exceed the Occupational Exposure Limit (OEL) without a respirator or additional controls?
  1) 0 samples?
  2) 1 sample?
  3) 5 samples?
  4) 10 samples?
  5) 25 samples?
  6) 50 samples?

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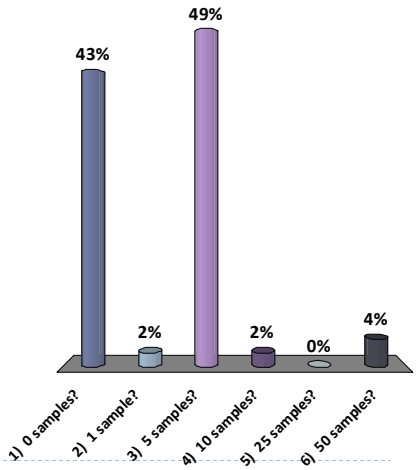
Data Interpretation Example

A. 1) 0 samples?
B. 2) 1 sample?
C. 3) 5 samples?
D. 4) 10 samples?
E. 5) 25 samples?
F. 6) 50 samples?



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How confident do you want to be in your previous decision?

1. 100% confident
2. 99% confident
3. 95% confident
4. 90% confident
5. 75% confident
6. 50% confident

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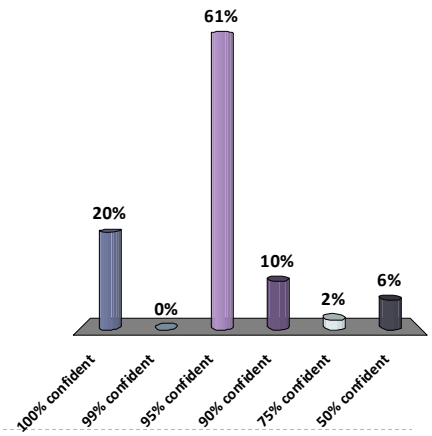
How confident do you want to be in your previous decision?

A. 100% confident
B. 99% confident
C. 95% confident
D. 90% confident
E. 75% confident
F. 50% confident



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Is the following exposure to Xylene acceptable?
Two samples collected (ppm) = **21, 68**
(Xylene TLV=100 ppm)

1. Yes
2. No

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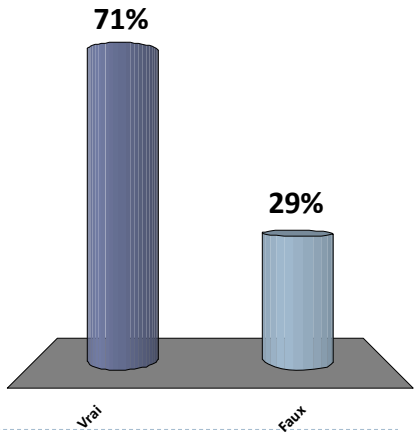
Is the following exposure to Xylene acceptable?
Two samples collected (ppm) = **21, 68**
(Xylene TLV=100 ppm)

A. Vrai
B. Faux



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Resume Presentation

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Data Interpretation Example

- Employee performs a job 100 times per year
- If you collected personal samples on the employee all 100 times, how many times is it acceptable for exposures to exceed the Occupational Exposure Limit (OEL) without a respirator or additional controls?

1) 0 samples?
2) 1 sample?
3) 5 samples?
4) 10 samples?
5) 25 samples?
6) 50 samples?

The majority of hygienists select the 5% Exceedence / 95% percentile for a Decision Statistic

Which Decision Statistic do you think most company managers would select?

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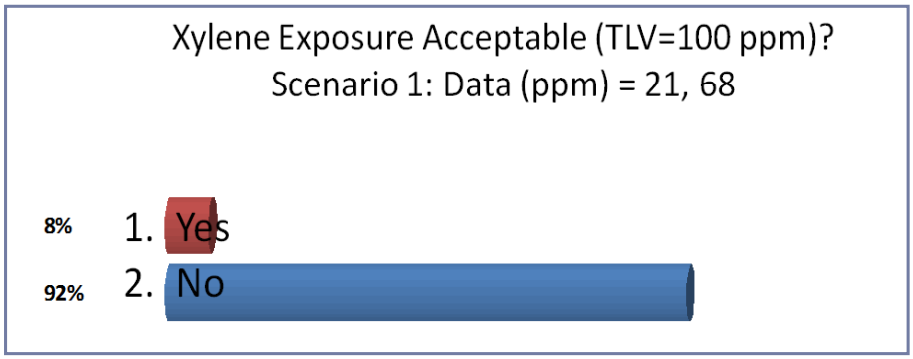
What did a group at the 2014 British Occupational Hygiene Society Conference say?



- Vast majority said – "Unacceptable"

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Reasons for exposure assessment (EA) programs…

1. Evaluate exposure control effectiveness
   - Ensure Health Protection – Verify all types controls - ventilation, administrative, personal protective equipment
2. Exposure surveillance and program effectiveness
   - Identify processes, tasks, industries with exposure risks
3. Understand exposure determinants
   - Equipment sources, processes, materials, tasks – which contribute most/lease to exposure
4. Provide exposure data for epidemiology and health surveillance
   - Detect health effects as early as possible to protect people
5. Determine regulatory compliance
   - Demonstrate majority of all exposures are below the OEL

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Selected Exposure Diagnosis Strategies

- NIOSH 1977
- AIHA 1991, 1997, 2006
- CEN 689
- REACh

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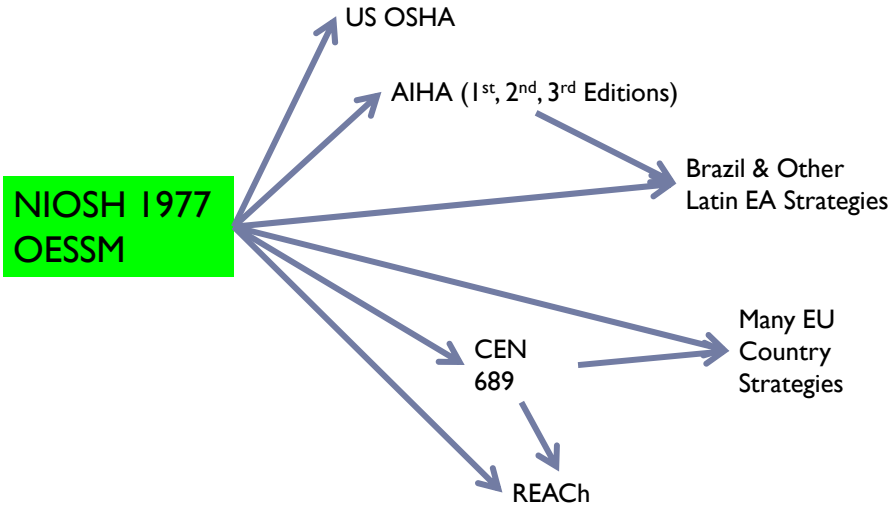
NIOSH OESSM Directly Influenced Most Major Exposure Assessment Strategies



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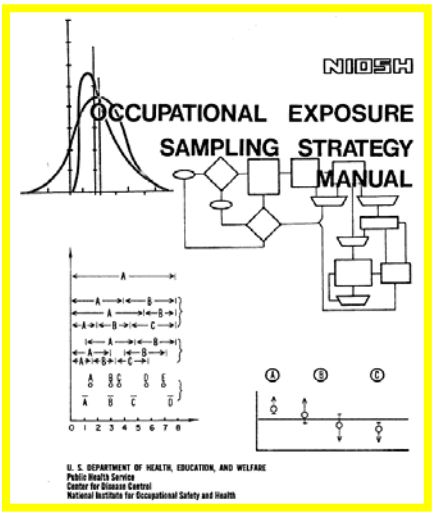
NIOSH Occupational Exposure Sampling Strategy Manual

- Based on NIOSH OESSM 1977
  Leidel, Busch and Lynch
- Objectives
  - assist employers to meet regulations
  - improve compliance decision making
  - for employee exposure monitoring
  - efficient monitoring program
  - minimize employer sampling burden
  - provide adequate employee protection

— devise sampling plans to evaluate occupational exposures to airborne concentrations of chemical substances,
— determine the need for exposure measurements,
— evaluate exposure measurement data, and
— make decisions concerning what action is required by Federal regulations such as 29 CFR 1910 Subpart Z.



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Important Concepts in OESSM

- Illustrated the collection of exposure determinant information
  - Defined structure for gathering exposure determinants (*"basic characterization"*)
- Structured process for making exposure decisions
  - Described initial / qualitative exposure assessments used for
- Formally introduced the concept of sensitizing rules or "Action Levels" used to create more efficient process
  - more health protective with taking less samples
- Explained use of statistical tools
  - log-probability plotting, sample size charts, equations for distributional parameters, confidence interval calculations

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NIOSH OESSM Decision Logic

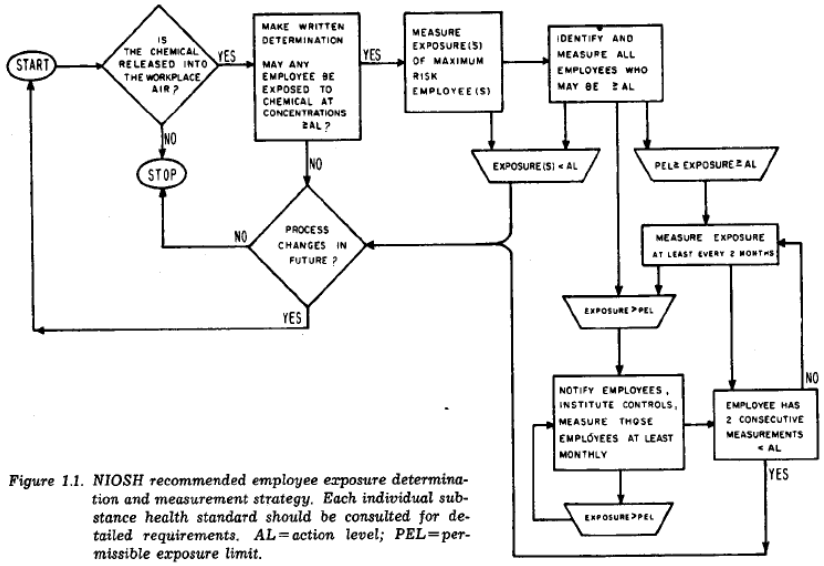

Figure 1.1. NIOSH recommended employee exposure determination and measurement strategy. Each individual substance health standard should be consulted for detailed requirements. AL=action level; PEL=permissible exposure limit.

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Limitations of OESSM

- Are there limitations?

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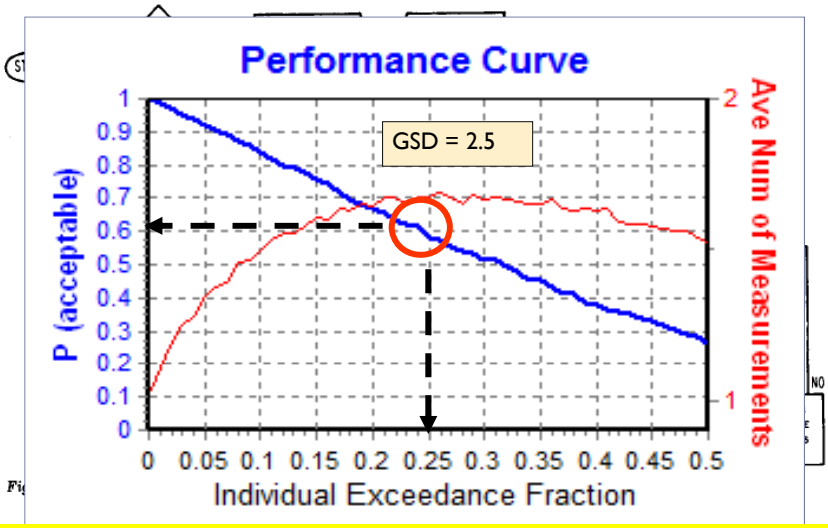
Performance of this Strategy?



For a job that exceeds the OEL 25% of the time, the strategy will incorrectly determine it to be "acceptable" ~60% of the time

Recommendations for OESSM

1. Methods to select a Decision Statistic for different types of assessments
2. Analyze performance (efficiency & effectiveness) of common sampling strategies
3. Comprehensive and effective methods for utilizing exposure control banding methods
4. Better define methods of exposure modeling techniques for qualitative assessments
5. Consider simple statistical strategies for noise, dermal and airborne agents without limits

Recommendations for OESSM

6. Define the manual's scope at a level that keeps it practical for the majority of hygienists
7. Consider the impact of new laboratory analytical equipment and field portable sampling devices
8. Updates on statistical and simulation methods
9. Task based sampling strategies should be added along with full shift strategies
10. Incorporate elements of NIOSH Document Exposure Measurement Action Level and Occupational Environmental Variability (76-131)

Sample 95th Percentile "Decision Statistic"

- The focus is on the upper tail of the exposure profile.
- The sample 95th percentile is the most common upper tail "decision statistic" but 90th and 99th are also used
- The (usual) goal is to determine which category the 95th Percentile most likely falls.
- It is used to assist in reaching a decision that the exposure profile is
  - "Controlled" or "Acceptable"
  - "Unacceptable"
  - or falls in an "Exposure Control Category"

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95th Percentile interpretation of TWA OELs

- NIOSH guidance
  - Employer should 95% confident that 95% of the exposures are ≤ the TWA PEL
  - Leidel, N.A., Busch, K.A., Lynch, J.R.: *Occupational Exposure Sampling Strategy Manual*. National Institute for Occupational Safety and Health (NIOSH) Publication No. 77-173 (available as a pdf file from NIOSH website) (1977).
- OSHA
  - Measured TWA exposures should "rarely" exceed the TWA PEL (preamble to the benzene PEL, 1987)

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95th Percentile interpretation of TWA OELs

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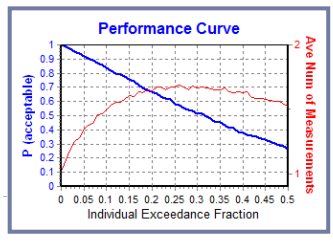
- OSHA
  - Measured TWA exposures should "rarely" exceed the TWA PEL (preamble to the benzene PEL, 1987)

Figure 4 is the primary technical basis for the recommendation of an action level of one half (0.5) the standard. It is felt that the employer should try to limit to 5% probability, that no more than 5% (or greater) of an employee's actual (true) daily exposure averages exceed the standard. Figure 4 shows that the action level for this low 0.05 probability (confidence of 95%) is a function of the interday variability of the true daily exposures (combined with an assumed sampling/analytical CV of 10%). Higher GSDs require lower fractional action levels. A GSD of 2.0 requires an action level as low as 0.115 of the standard!



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95th Percentile interpretation of TWA OELs

- ACGIH
  - Roach, S.A., Baier, E.J., Ayer, H.E., and Harris, R.L.: Testing compliance with Threshold Limit Values for respirable dusts. *American Industrial Hygiene Association Journal* 28:543-553 (1967).
  - Stokinger, H.E.: Industrial air standards - theory and practice. *Journal of Occupational Medicine* 15:429-431 (1973).
  - Still, K.R. and Wells, B.: Quantitative Industrial Hygiene Programs: Workplace Monitoring. (Industrial Hygiene Program Management series, part VIII). *Applied Industrial Hygiene* 4:F14-F17 (1989).

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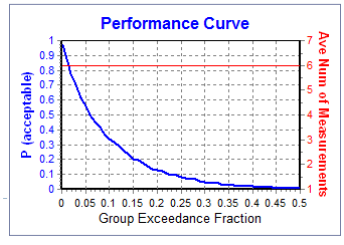
95th Percentile interpretation of TWA OELs

- AIHA 1991 and 1998 guidance
  - Employer should maintain true group or individual upper percentile exposure < TWA OEL
  - "Similar Exposure Group" 95th percentile exposure < TWA OEL
- Ex-OSHA director:
  - Corn, M. and Esmen, N.A.: Workplace exposure zones for classification of employee exposures to physical and chemical agents. *American Industrial Hygiene Association Journal* 40:47-57 (1979).



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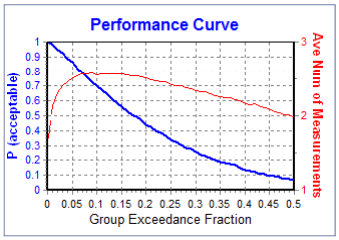
95th Percentile interpretation of TWA OELs

- EU
  - CEN (Comité Européen de Normalisation):Workplace atmospheres - Guidance for the assessment of exposure by inhalation of chemical agents for comparison with limit values and measurement strategy. European Standard EN 689, effective no later than Aug 1995 (English version) (Feb 1995).



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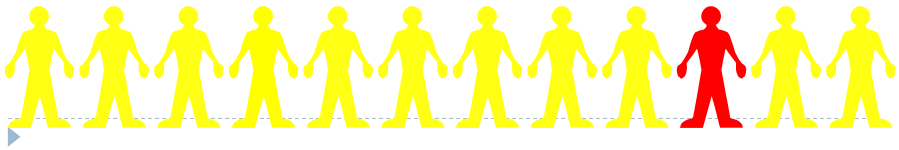
OSHA Compliance Strategy:

Is a worker's exposure "in compliance" on one single day?

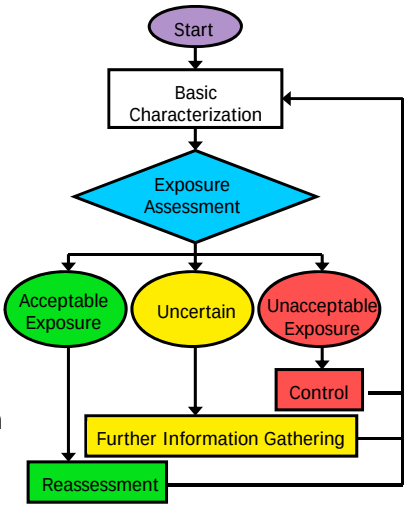
Health Risk Management Strategy:

Are ALL workers protected nearly EVERYDAY?



AIHA's Exposure Assessment & Control Banding Strategy

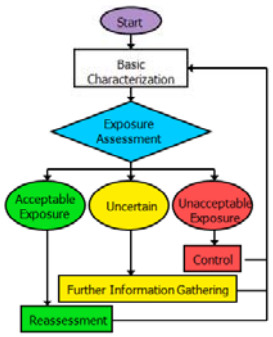
- Strategy is focused on <u>efficient AND effective decision making</u>
- Exposure & Control Bands are in fractions and multiples of the exposure limit
  - <10% of exposure limit
  - 10-50% of exposure limit
  - 50-100% of exposure limit
  - >100% of exposure limit
- Flexible Efficient and Effective System for Exposure Risk Prioritization, Health Protection Continuous Improvement

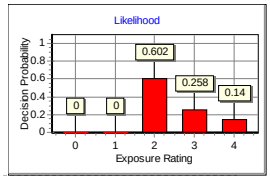


Exposure Assessment Strategy

- Basic Characterization
- Exposure Assessment
  - Define similar exposure groups (SEGs)
  - Define the exposure profile
  - Judge acceptability of the profile for each SEG
- Further information gathering
- Control measures
- Re-assessment
- Communication and documentation
- Implementation

Reflects iterative "continuous improvement cycle" or real-world assessment programs Assessment include a combination of qualitative and quantitative information

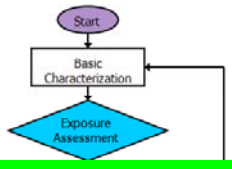




34 Exposure Assessment Strategies and Statistics - 1 Day PDC

Exposure Assessment Strategy

- Basic Characterization
- Exposure Assessment
  - Define similar exposure groups (SEGs)
  - Define the exposure profile



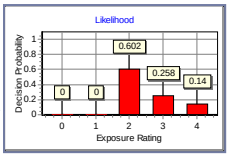
This Strategy works for both prospective and retrospective exposure assessment and management!

- Communication and documentation
- Implementation

Reflects iterative "continuous improvement cycle" or real-world assessment programs Assessment include a combination of qualitative and quantitative information

What is unique about the AIHA EA Strategy?

- Comprehensive approach to documenting ALL qualitative exposures and then prioritizing them for sampling and/or control programs
- New integrated Bayesian methods create a transparent method for testing the accuracy of qualitative and semi-quantitative (i.e., modeling based) assessments
- It is the only fully integrated exposure assessment and control banding strategy published to date.



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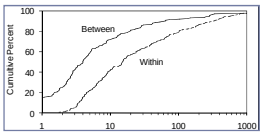
Example Exposure Assessment and Control Category Follow-up (i.e., *Banding*)

	Exposure Control Category**	Recommended Control
	0 (<1% of OEL)	No action
	1 (<10% of OEL)	general HazCom
	2 (10-50% of OEL)	+ chemical specific HazCom
	3 (50-100% of OEL)	+ exposure surveillance, medical surveillance, work practices
	4 (>100% of OEL)	+ respirators & engineering controls, work practice controls, validate respirator selection
	5 (Multiples of OEL; e.g., based on respirator APFs)	+ immediate engineering controls or process shutdown, validate respirator selection

- ** - Decision statistic = 95th percentile

The heart of the AIHA Exposure Assessment Strategy is Exposure & Control Banding

- Exposure Categories 0-1 (<10% of the OEL)
  - Document low exposures for health surveillance and epidemiological purposes
  - Validate a limited selection of qualitative assessments to ***strengthen "professional judgment"***
- Exposure Categories 2-3 (between 10-100% of the OEL)
  - Highest sampling burden
  - Understand within / between worker variability



- Exposure Categories 4+ (>100% of the OEL)
  - Implement management and control programs using the hierarchy of controls

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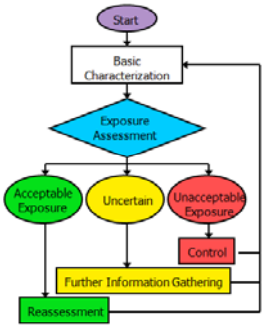
Top 5 aspects of a good exposure assessment strategy

1) Must incorporate both qualitative (professional judgment) **and <u>quantitative</u>** (sampling) aspects of exposure assessment

- This critical aspect builds efficiency and strengthens professional judgment



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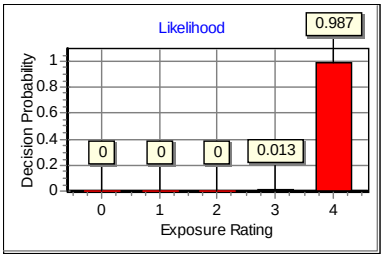
Top 5 aspects of a good exposure assessment strategy



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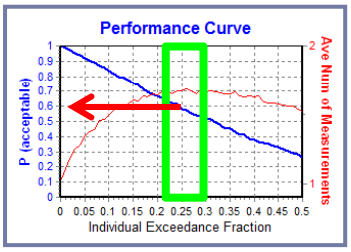
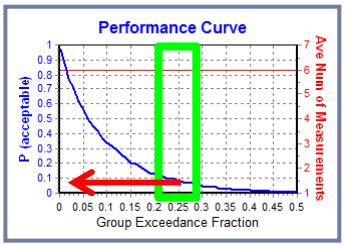
Top 5 aspects of a good exposure assessment strategy

2) Effective strategy = i.e., the strategy will accurately detect both

- ***unacceptable*** (exposures that need controls) work environments
- ***acceptable*** (no additional controls needed) work environments





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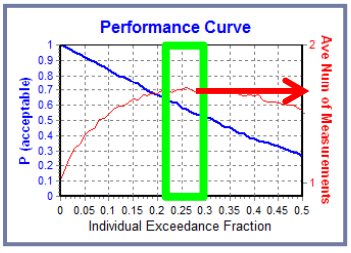
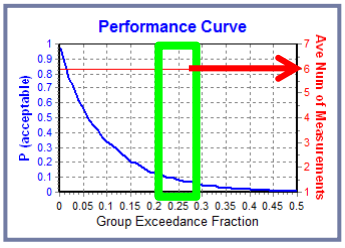
Top 5 aspects of a good exposure assessment strategy

3) Efficient Strategy – How many samples are needed to make a "correct" decision?





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Top 5 aspects of a good exposure assessment strategy

4) Easy to <u>understand</u> AND <u>implement</u>…

"Be as simple as possible,... but no simpler"

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Top 5 aspects of a good exposure assessment strategy

5) Achieve multiple objectives at the same time

- Evaluate exposure control effectiveness (Protect Health!)
- Exposure surveillance and program effectiveness
- Understand exposure determinants
- Provide exposure data for epidemiology and health surveillance
- Determine regulatory compliance

…a well designed and IMPLEMENTED strategy will meet all of these objectives at the same time

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Questions / Comments?

THANK YOU!!!

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EXTRA SLIDES….

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CONTENTS

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Exceedance Fraction Point Estimate

An exceedance fraction is an estimate of the proportion of the exposure distribution that is greater than some exposure level, such as an OEL. The equation for the exceedance fraction (f) for a lognormal distribution has an odd format:

$$f = P(c > OEL) = P\left(Z > \frac{\ln OEL - \bar{y}}{s_y}\right)$$

If this were stated in words, it would read: "The exceedance fraction equals the probability (P) that a concentration (c) in the exposure profile is greater than the OEL. This equals the probability that a Z-value (Z) from the distribution exceeds the calculated Z-value corresponding to the position of the OEL in the distribution $[(\ln OEL - \bar{y})/s_y]$.

The procedures for calculating the exceedance fraction is as follows, demonstrated by the previous monitoring data (see Table IV.8).

1. Calculate the Z-value corresponding to the position of the OEL in the exposure distribution.

$$Z_{OEL} = \frac{\ln OEL - \bar{y}}{s_y}$$

$$Z_{OEL} = \frac{\ln(5) - 0.91}{0.41}$$

$$Z_{OEL} = 1.706$$

2. Look up the proportion of a normal distribution corresponding to Z_{OEL} in a Z-table (see Table IV.11).

$$P = 0.9564$$

3. Subtract the proportion from 1 to determine the exceedance fraction.

$$f = 1 - P$$

$$f = 1 - 0.9564$$

$$f = 0.0436 = 4.4\%$$

Confidence Intervals for the Exceedance Fraction

The following procedure calculates one-sided 95% confidence limits for the exceedance fraction.[3] Together, the upper and lower confidence limits form a two-sided 90% confidence interval. The procedure consists of the following two steps, demonstrated using the previous monitoring data (see Table IV.8).

1. Calculate ZOEL (the same value used to obtain the point estimate of the exceedance fraction).

$$Z_{OEL} = \frac{\ln OEL - \bar{y}}{s_y}$$

$$Z_{OEL} = \frac{\ln(5) - 0.91}{0.41}$$

$$Z_{OEL} = 1.706$$

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2. Using ZOEL and the sample size, n, read the confidence limit from Figure IV.10. This value represents the 95% LCL for f.

95% LCL(Z_{OEL},*n*) = 95% *LCL*(1.706,15):0.02 95% *LCL for f* = 0.02 (*or* 2%)

Using *negative* Z_{OEL} and n read the confidence limit from Figure IV.110. This 95% UCL for f is the complement of this value (complement = 1 - value).

$$95\%\ UCL\left(-Z_{OEL},n\right)=95\%\ UCL\left(-1.706,15\right):0.85$$

$$95\%\ UCL\ \ for\ \ f=1-0.85$$

$$95\%\ UCL\ \ for\ \ f=0.15\ \left(or\ 15\%\right)$$

For most data sets, Figures IV.11 and IV.12 should be used. These figures cover a portion of Figure IV.10 and will often result in more accurate estimates of the LCL and UCL, respectively. Note that in Figure IV.12 the 95% UCL is read directly from the y-axis.

In summary, the industrial hygienist can conclude with 95% confidence that exposures exceed the 5 mg/m^3 OEL no more than 15% of the time.

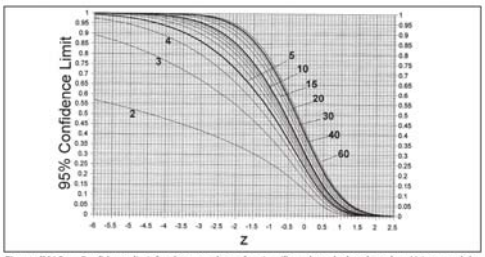

Figure IV.10 — Confidence limit for the exceedance fraction (f) vs. the calculated z-value. Using z and the sample size, read the 95th percentile LCL from the y axis. Using negative z and the sample size, read the corresponding y axis value. The 95th percentile UCL is the complement of this value (complement = 1 – value). [From **Hewett, P., and G.H. Ganser:** Simple Procedures for Calculating Confidence Intervals Around the Sample Mean and Exceedance Fraction Derived from Lognormally Distributed Data. *Appl. Occup. Environ. Hyg.* 12(2):132-142 (1997). Reprinted with permission of the American Conference of Governmental Industrial Hygienists.]

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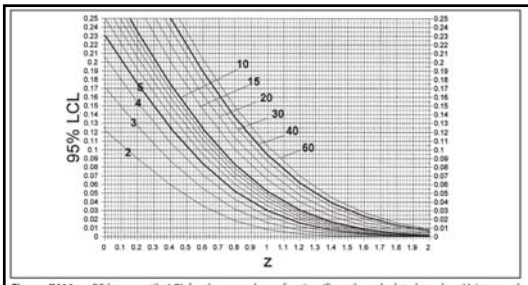

Figure IV.11 — 95th percentile LCL for the exceedance fraction (f) vs. the calculated z-value. Using z and the sample size, read the 95th percentile LCL from the y axis. [From **Hewett, P., and G.H. Ganser:** Simple Procedures for Calculating Confidence Intervals Around the Sample Mean and Exceedance Fraction Derived from Lognormally Distributed Data. *Appl. Occup. Environ. Hyg.* 12(2):132-142 (1997). Reprinted with permission of the American Conference of Governmental Industrial Hygienists.]

Appendix IV — Descriptive Statistics, Inferential Statistics, and Goodness-of-Fit —373

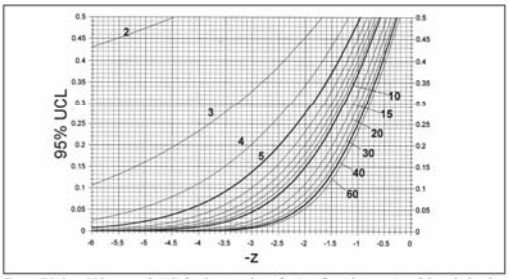

Figure IV.12 — 95th percentile UCL for the exceedance fraction (f) vs. the negative of the calculated z-value. Using -z and the sample size, read the 95th percentile UCL from the y axis. [From **Hewett, P., and G.H. Ganser:** Simple Procedures for Calculating Confidence Intervals Around the Sample Mean and Exceedance Fraction Derived from Lognormally Distributed Data. *App. Occup. Environ. Hyg.* 12(2):132-142 (1997). Reprinted with permission of the American Conference of Governmental Industrial Hygienists.]

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1. A historical perspective on occupational exposure sampling strategies
2. American Industrial Hygiene Association's (AIHA) approach to overexposure diagnosis
3. Overview of Other Modern approaches to occupational exposure diagnosis

- All part of session – "Exceedance probability of threshold values to diagnose exposure to chemicals in the workplace" beginning at 10:35 and 14:40
- Panel Presentation at 1600 – "Applying exceedance probability to estimate risk of overexposure to chemicals: advantages and limits"

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Top Recommendation – Comprehensive Sampling Strategy

- Baseline sampling strategies & their performance
  - When do I need to sample?
    - Incorporate Qualitative Exposure Assessments
    - Show the performance of several strategies using simulations
- Surveillance sampling strategies
  - How do I confirm that exposures continue to be in control?
    - Especially critical for AIHA Category 2 & 3
- Control termination strategies
  - When can I take a person out of…
  - Respirators, medical surveillance, hearing conservation programs,
- Epidemiology - Need to understand central tendency for individuals & groups of workers
  - How can we accurately link exposures to outcomes?

Different Statistics & Different Decisions

- OSHA Compliance
  - Is the worker over the PEL (CV adjusted), today?
- NIOSH / AIHA Strategy
  - Are most workers protected most of the time with high confidence?
- Epidemiological Studies
  - What is the "average" or median (or ceiling) exposure category for a group of workers?

…using only one approach will cause confusion and create judgment bias …

Framing the Decision Statistic

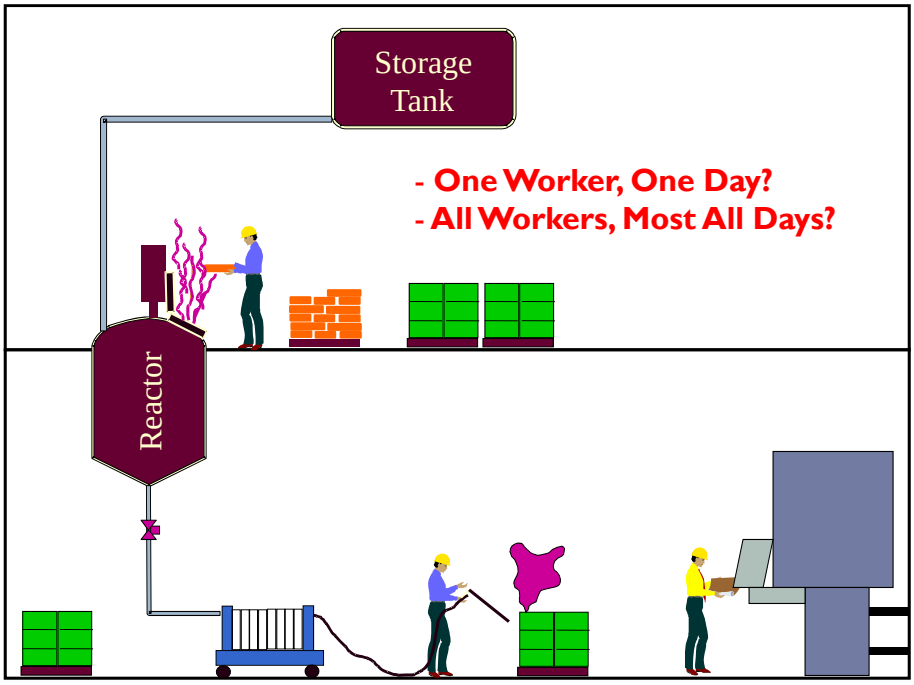
- The "Decision Statistic" is the metric (upper tail or central tendency) used to make a decision
  - Examples:
    - Sample collected last week is below the compliance limit
    - 95th percentile below the TLV
    - Geometric Mean (GM) is in 1-10% of TLV category

OSHA Compliance

Protect Workers on Most Days!

Exposure Matrix in Epi Study

- The 1977 manual doesn't explicitly define different "Decision Statistics" creating a source of confusion.



Framing the Decision Statistic

- Employee performs a job 100 times per year
- If you collected personal samples on the employee all 100 times, how many times is it acceptable for exposures to exceed the Occupational Exposure Limit (OEL) without a respirator?
  - 0 samples?
  - 1 sample?
  - 5 samples?
  - 10 samples?
  - 25 samples?
  - 50 samples?

The majority of hygienists select the 95% percentile for a Decision Statistic

Which Decision Statistic do you think most company managers would select?

Retrospective or Prospective

- Would you have answered the question differently if it was a retrospective exposure assessment?

Central Tendency for Retrospective

Upper Tail for Prospective

Lets be clear, we need both!!!

From Chapter 4 (OESSM '77)

What is the Decision

Chapter 3 discussed how the employee ex-
posure measurement
le
u
th
to
su

OESSM needs to provide clarification on when to use each different Decision Statistic

#1 - Exposure is OK for one day!

average [TWA]) on a particular day?

- What is an employee's long-term exposure estimate based on several exposure measurement daily averages?

#2 – Geometric mean exposure?

- What is the percentage of days an employee can be expected to be exposed to above-standard levels, based on several exposure measurement daily averages?

#3 - Exceedance Fraction

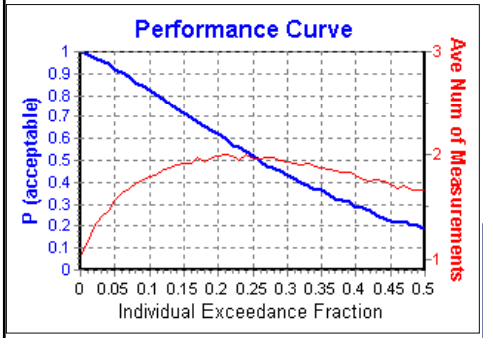
- Should engineering controls be installed to reduce excessive exposures?

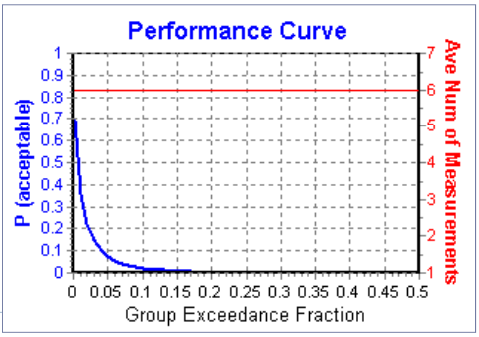
#4 - 95th Percentile below the PEL

Analyze Various Sampling Strategies

- Simulations illustrate the ***efficiency*** (# of samples) and ***effectiveness*** (probability of making a correct decision) for different sampling strategies
  - OSHA / NIOSH 6b
  - AIHA approach
  - CEN 689 (European Sampling Strategy)
  - Other approaches

Design strategies to match the Decision Statistic & Certainty!





The employer should be confident that no employee is being overexposed. Thus the action level was set with the philosophy that the employer should minimize the probability that even a very low percentage of actual daily employee exposure (8-hour TWA) averages exceed the standard. That is, the employer should monitor employees in such a fashion that he has a high degree of confidence that a very high percentage of actual daily exposures are below the standard.

(7) If two consecutive employee exposure measurements taken at lease one week apart reveal that the employee is exposed to 2-butanone below the action level, the employer may terminate measurement for the employee.

(8) For purposes of this paragraph employee exposure is that which would occur if the employee were not using a respirator.

Figure 4 is the primary technical basis for the recommendation of an action level of one half (0.5) the standard. It is felt that the employer should try to limit to 5% probability, that no more than 5% (or greater) of an employee's actual (true) daily exposure averages exceed the standard. Figure 4 shows that the action level for this low 0.05 probability (confidence of 95%) is a function of the interday variability of the true daily exposures (combined with an assumed sampling/analytical CV of 10%). Higher GSDs require lower fractional action levels. A GSD of 2.0 requires an action level as low as 0.115 of the standard!

Figure 4 was prepared using an assumed 10% sampling and analytical coefficient of variation (CV). This corresponds to a measurement method with about a 20% accuracy at a confidence level of 95%. However, the curves are labeled for "pure" interday variability. It is very important to realize that the measurement method error makes a very minor contribution to the calculated employee risk of having a given percentage of the true daily averages exceed the standard. The calculated risk is almost solely a function of the day to day variability.

Figure 4 shows that employees with day to day daily exposure average variabilities less than about 1.22 (combined with a sampling/analytical CV of 10%) have less than 5% probability of having 5% of their true daily exposures exceed the standard on unmeasured days. It is felt that very few interday variabilities are less than 1.22. Note that if one measured daily exposure average is at one half the standard then the following probabilities exist that at least 5% of the unmeasured true daily averages exceed the standard:

Interday Variability	Probability
GSD = 1.3	17%
= 1.5	47%
= 2.0	72%
= 3.0	83%

CV Coefficient of variation, a measure of relative dispersion (variability) of a normal distribution. Also known as the relative standard deviation and is defined as (σ/μ)

In general, the best procedure for determining the maximum risk employee is to observe and select the employee closest to the source of the hazardous material being generated. For exam-

The primary consideration of the action level is to protect employees from overexposures (exposures exceeding the permissible exposure limit). The employer should minimize the possibility for each employee that even a low percentage of the true daily exposure (8-hour TWA) averages exceed the standard. Stated differently, the employer should monitor each employee in such a fashion that there is a high degree of confidence that each employee has a high percentage of actual daily exposures below the standard.

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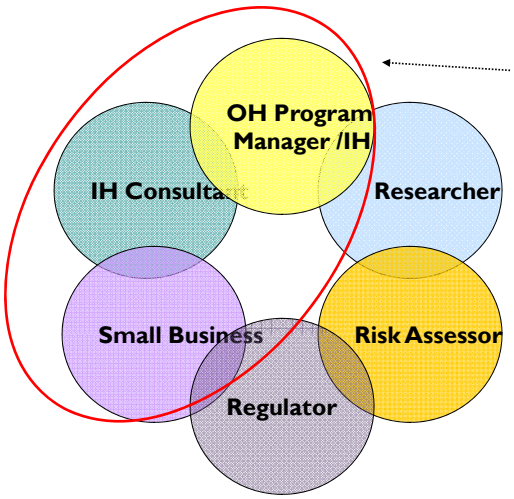
Exposure Assessor Roles



most exposure data are collected by employer representatives

role ⟷ type of exposure assessment

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