ADVANCING EXPOSURE JUDGEMENTS

CURRENT PRACTICE LIMITATIONS
AND
AMERICAN INDUSTRIAL HYGIENE ASSOCIATION
PRINCIPLES OF GOOD PRACTICE

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*The statements in this presentation are my own and are not representative of my employer.

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BACKGROUND

• Studies have shown that the accuracy of industrial hygiene exposure judgments is often poor[,], sometimes not statistically different from random chance[2,3], and tends to be biased low[1,].

• AIHA and ACGIH have developed an initiative, to drive a significant shift in the OEHS practice paradigm: where the use of tools and activities to improve exposure judgment accuracy is routine and expected.

1: Logan, P., G. Ramachandran, J. Mulhausen and P. Hewett. (2009). Occupational exposure decisions: can limited data interpretation training help improve accuracy? Annals of occupational hygiene, 53(4), 311-324.

2: Vadali, M., G. Ramachandran, J. Mulhausen, and S. Banerjee: Effect of training on exposure judgment accuracy of industrial hygienists. J. Occup. Environ. Hyg. 9(4):242–256 (2012).

3: Arnold, S. F., Stenzel, M., Drolet, D., & Ramachandran, G. (2016). Using checklists and algorithms to improve qualitative exposure judgment accuracy. J. Occup. Environ. Hyg., 13(3), 159-16

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COMMON PRACTICE LIMITATIONS

1. Sole reliance on professional judgement. IHs identify employees that they believe have the potential for the highest exposures because of their job tasks. Similar Exposure Groups (SEG) not systematically characterized by determinants of exposure (process, task, controls, etc.).

2. Limited sampling and analysis performed, typically: 1-2 samples per SEG, results compared directly to OELs. Reliance on biased sampling.

3. Exposure assessments tend to be isolated, not part of a formal management system.

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LIMITATION 1. PROFESSIONAL JUDGEMENT

• Challenging, if not impossible to identify and prioritize exposures with information overload associated with workplaces.

• Practitioners should leverage checklists and modeling tools in conjunction with professional judgement to characterize exposures.

• This approach better informs a sampling plan and can be more readily incorporated into an exposure management system.

Example: exposures characterized strictly by job title, will miss the following exposure determinants; Location, process, equipment, conditions, production rate/quantity, material, task, hours/shifts, # workers, duration/frequency, engineering controls

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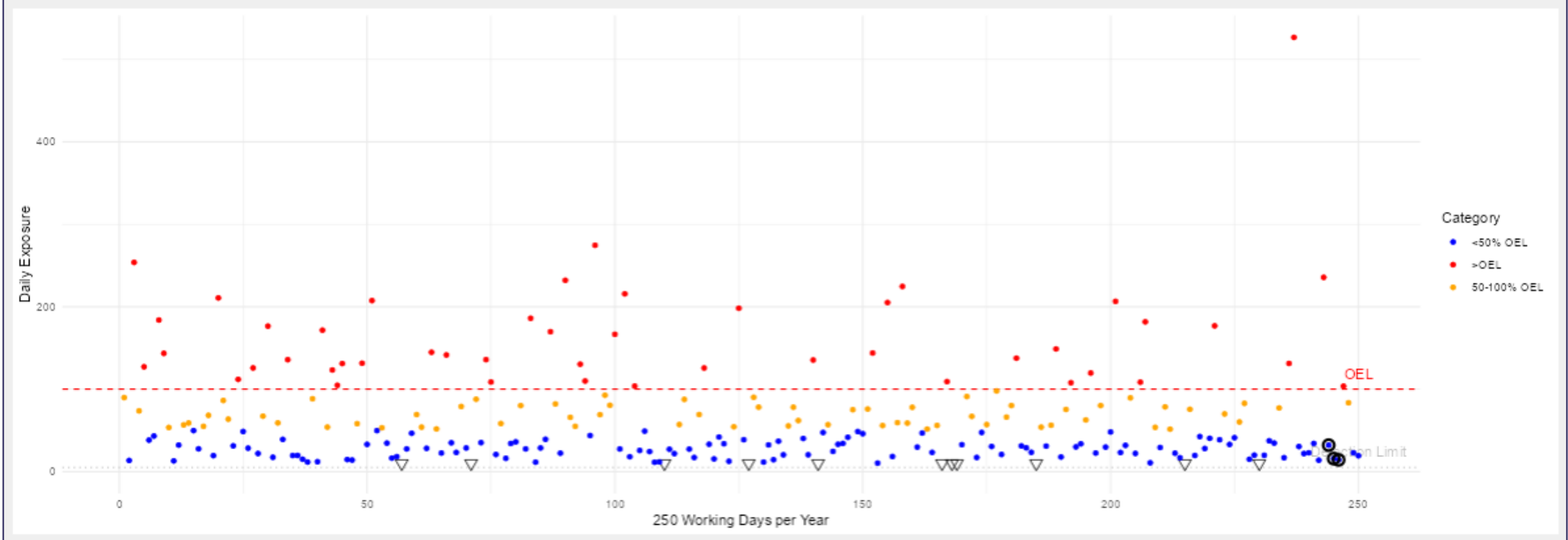# LIMITATION 2. SAMPLING – RESULTS>OEL

Exposure Simulation Results - 250 Working Days
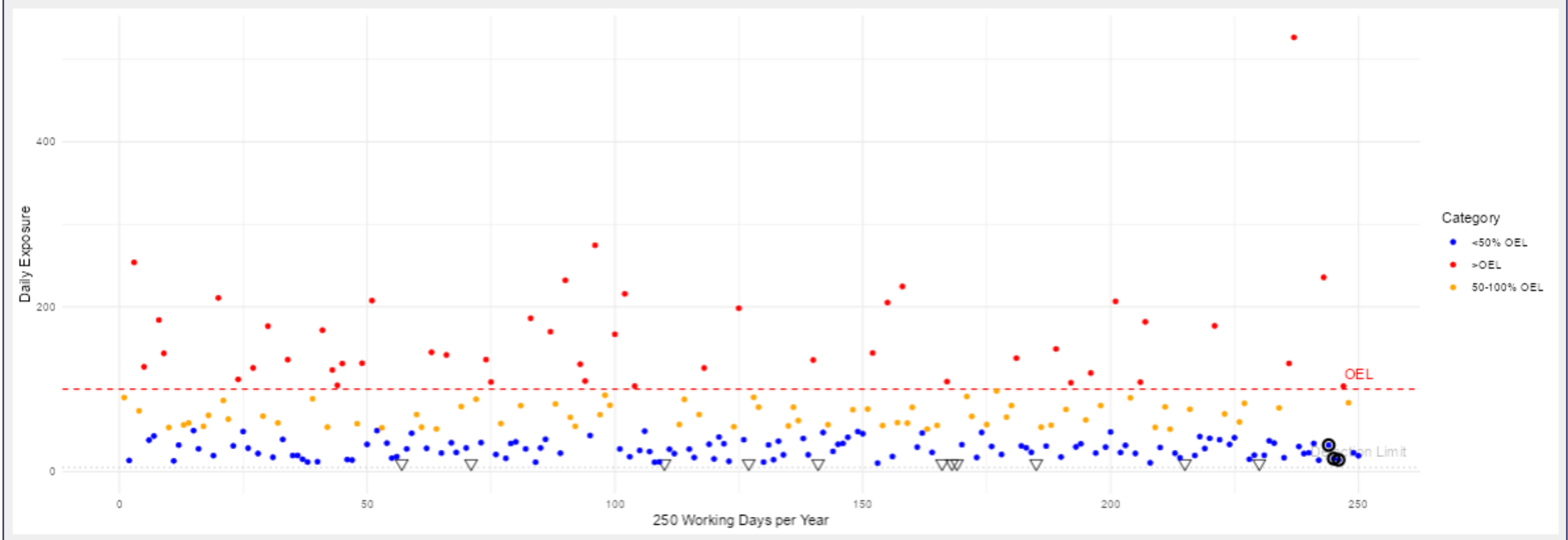
How accurate in %, would you want to be as an IH in being able to identify an overexposure in this situation?

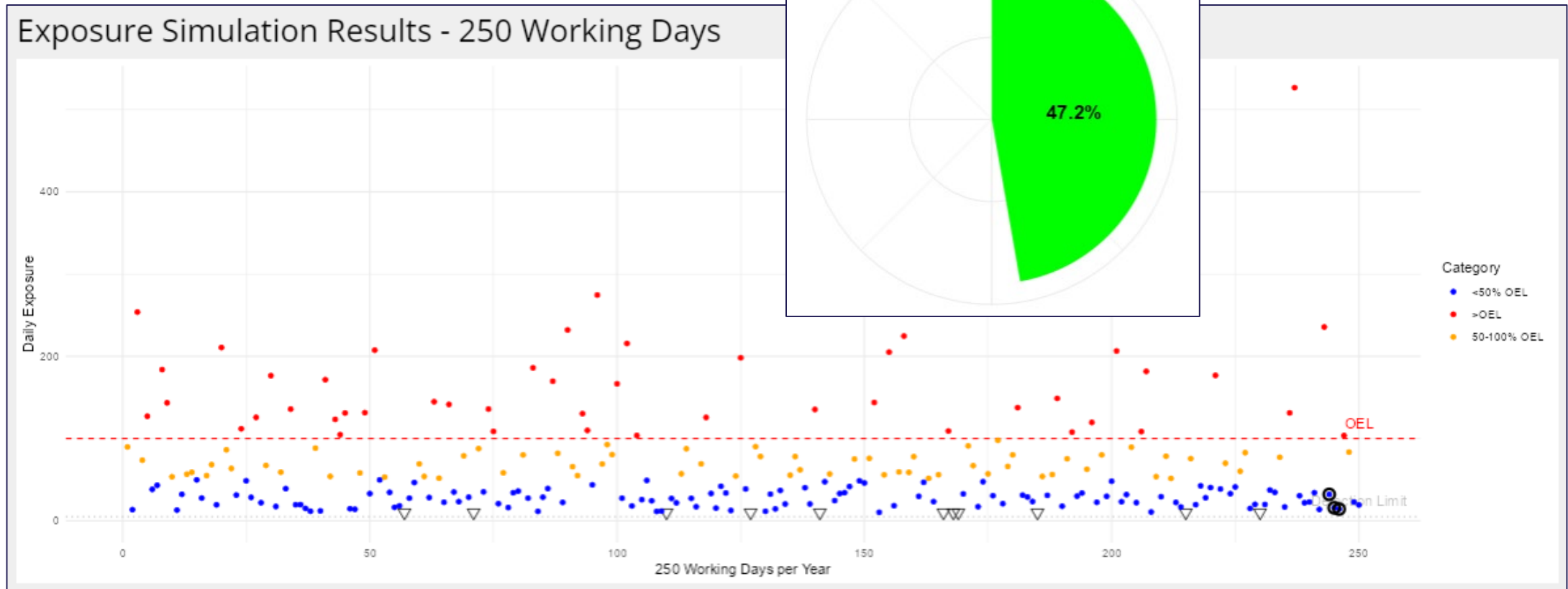# LIMITATION 2. SAMPLING – RESULTS>OEL

What is the likelihood of seeing an overexposure in 3 samples collected from this exposure?
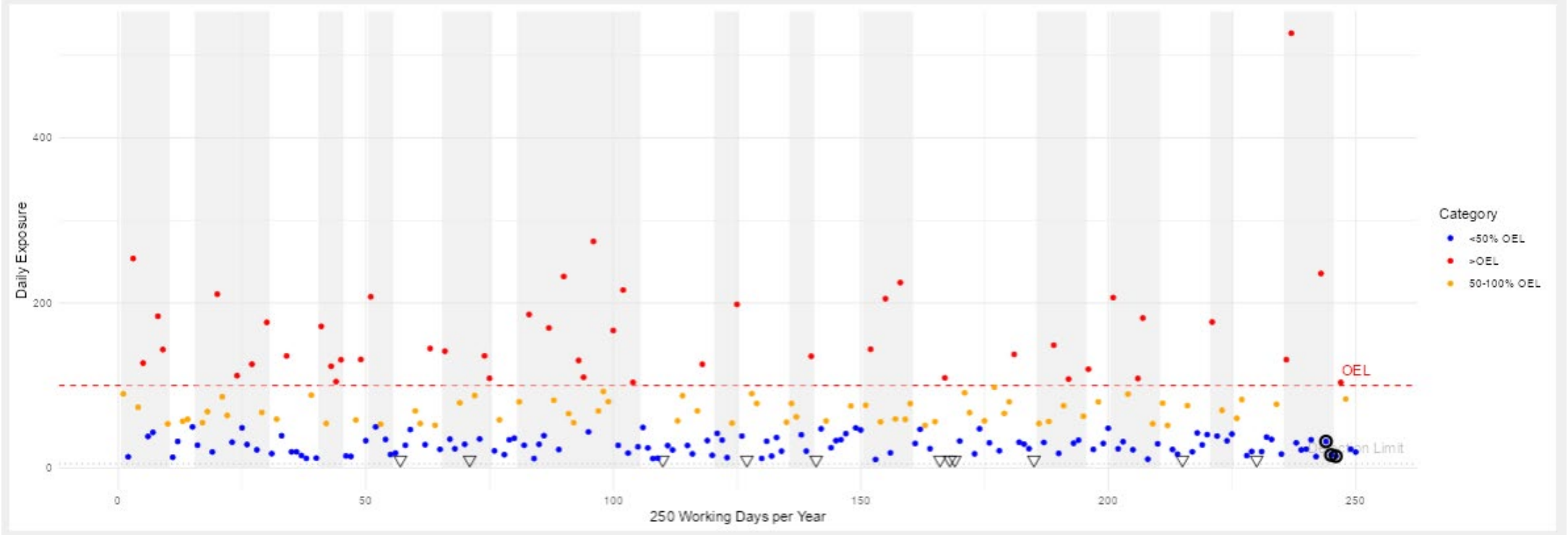
LIMITATION 2. SAMPLING [...] OEL

What is the likelihood of seeing an overexposure in 3 samples collected from this exposure?

LIMITATION 2. SAMPLING – RESULTS>OEL +BIAS

Exposure Simulation Results - 250 Working Days

Bias to top 50% of average 5-day exposures. Now, what is the likelihood of seeing an overexposure in 3 samples collected from this exposure?

LIMITATION 2. SAMPLING   OEL +BIAS

Exposure Simulation Results - 250 Working Days
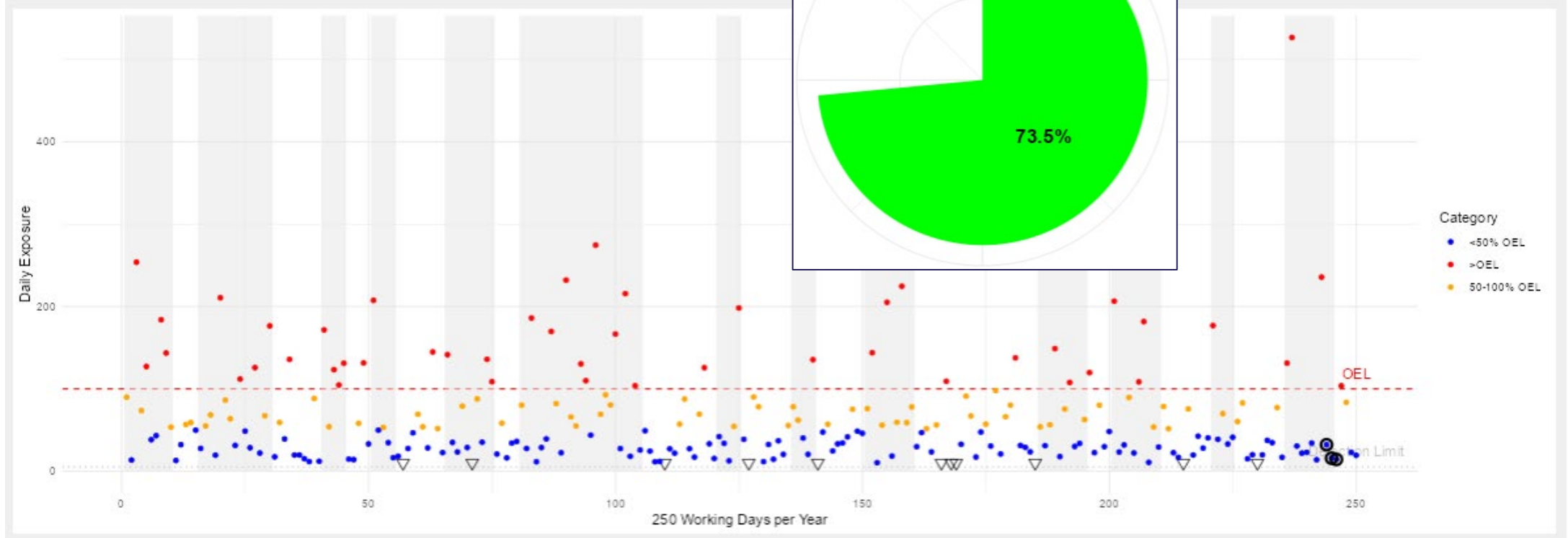
73.5%

Category
- <50% OEL
- >OEL
- 50-100% OEL

Bias to top 50% of average 5-day exposures. Now, what is the likelihood of seeing an overexposure in 3 samples collected from this exposure?

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LIMITATION 2. SAMPLING – INFERENTIAL STATISTICS

Inferential statistics. 70% UCL 95th percentile. Results with n=3 (n=6+ samples recommended).

LIMITATION 2. SAMPLING – INFERENTIAL STATISTICS

Exposure Simulation Results - 250 Working Days
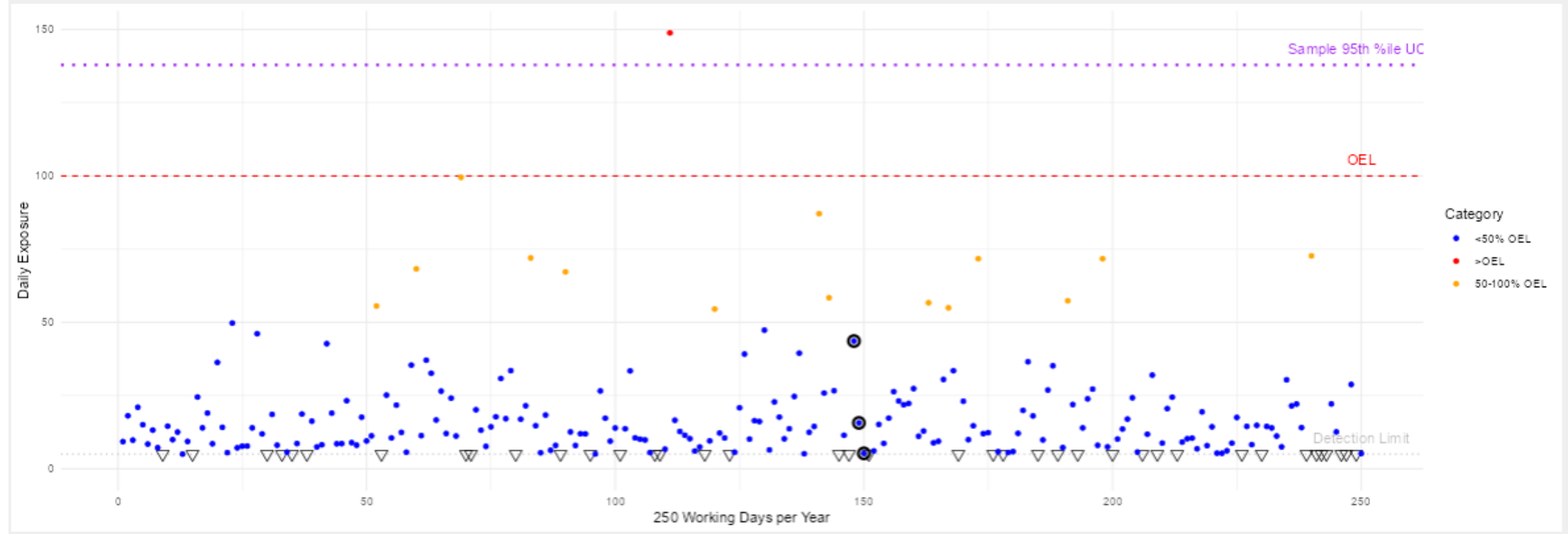
Inferential statistics. 70% UCL 95th percentile. Results with n=3 (n=6+ samples recommended).

LIMITATION 2. SAMPLING – ICS

70,95 UTL Below Criteria

Below Criteria   N=3 <OEL
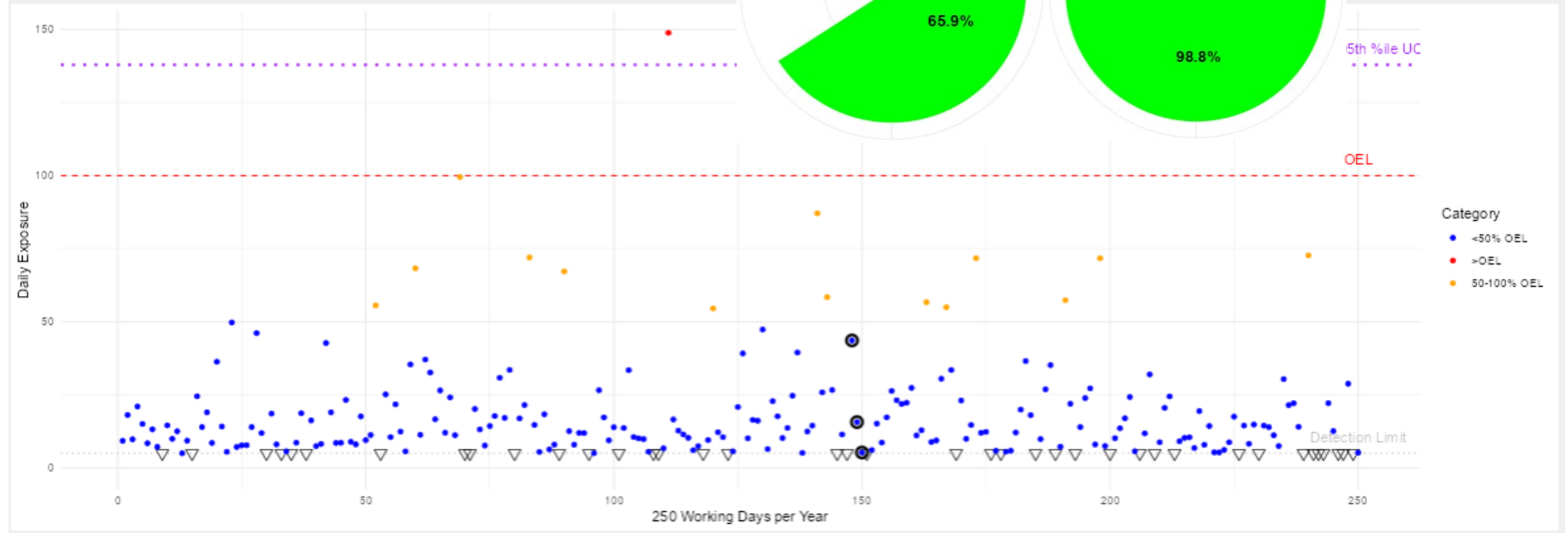
Exposure Simulation Results - 250 Working Days

Inferential statistics. 70% UCL 95th percentile. Results with n=3 (n=6+ samples recommended).

LIMITATION 3. EXPOSURE MANAGEMENT

- Exposure assessments are sometimes performed in isolation and may not be reviewed or updated as changes occur.

- Workplaces are dynamic, exposure assessments should be too.

- Management systems allow for:
  - Prioritization through risk ranking
  - Optimization of resources (controls and sampling)
  - Change management
  - Easy auditing
  - Record organization and retention

INITIATIVES

In 2022 AIHA Introduced Four Initiatives

Initiative	Purpose
AIHA – ACGIH Defining the Science	Advance our science to improve the ability of practitioners to protect workers and communities.
Principals of Good Practice	Define minimum practice performance expectations for ensuring acceptable worker protection.
State of the Art vs. Practice	Implement a continuous improvement strategy to close gaps between current practice and the state of the art and minimum standards of care.
AIHA – ACGIH Improving Exposure Judgements	Accelerate adoption of the use of IH statistical and other tools to improve the accuracy of worker exposure assessments.

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PGP ADVANTAGES

- Reasonable for all OEHS practitioners around the world.

- Targets for continuous improvement strategies to meet or exceed over time.

- Implementation speed will vary (depends on size of the gap, resources available, etc.).

- For use by single organization practitioners and by consultants advising multiple clients.

- Include best practice criteria to inspire continuous improvement efforts.

PGP LIMITATIONS

- Time-sensitive: based on practices documented at the time of publication.
- Not comprehensive or complete. No rigorous review was conducted of every guidance, standard, and regulation around the world.
- Not a consensus of AIHA or the profession.
- Not intended as legal expectations, "requirements of practice", or "standards".
- Not equivalent to "minimum acceptable practice" which is primarily driven by regulatory requirements.
- There may be alternate approaches more efficient and effective than those in the PGP.

PGP SUGGESTED IMPLEMENTATION STRATEGY

5. Verify implementation progress and effectiveness. Identify where plan objectives were not fully met for consideration in the next round of improvement.

1. Compare the PGP to your current practices to identify opportunities for improvement.

2. Prioritize the opportunities for improvement.

4. Implement the plan and track progress against the plan's SMART objectives.

3. Develop a plan with SMART objectives to close the higher priority gaps.

5. Verify

1. Identify Gaps

Continuous Improvement

2. Prioritize

4. Implement

3. Plan

Straightforward Integration Into Existing Management Systems (e.g. ISO 45001, RCMS 14001)
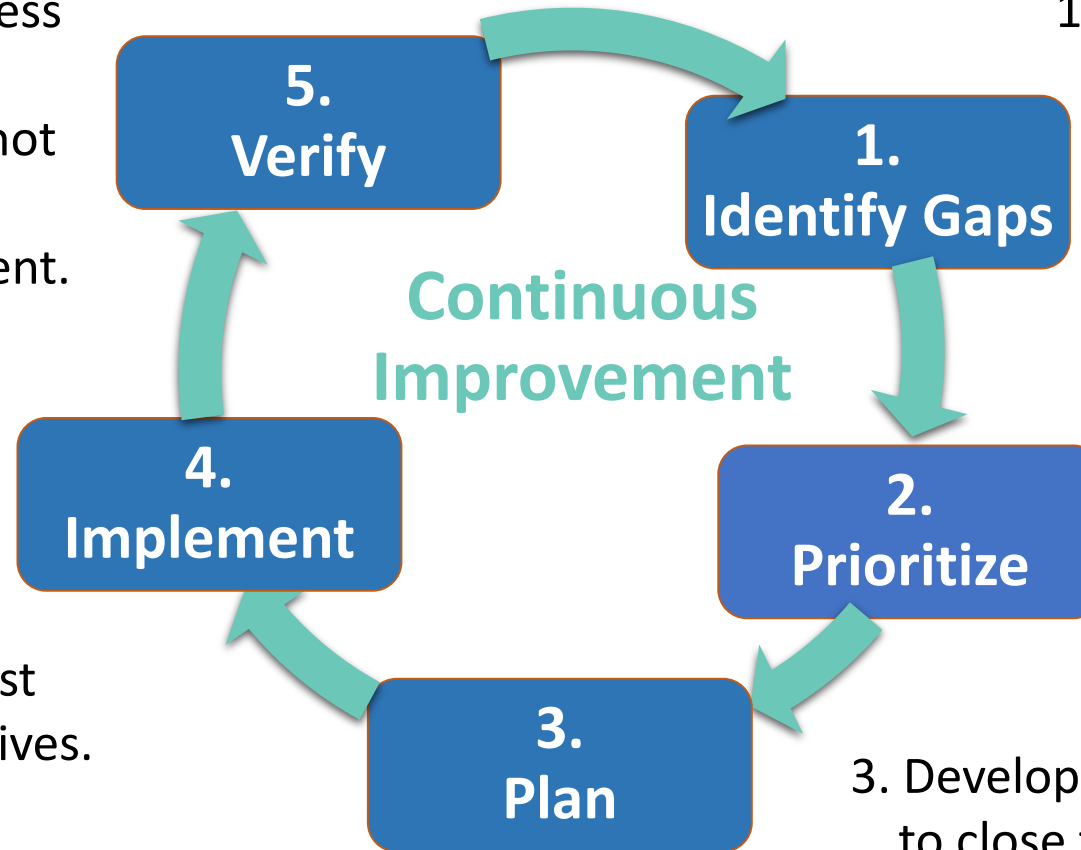
CONTINUOUS IMPROVEMENT PROCESS

Prioritized Movement Up the Hierarchies:

More Robust

Hierarchy of **OELs**		Hierarchy of **Exposure Assessment**		Hierarchy of **Exposure Controls /Management**	
Health Based OEL Traditional		Validated Monitoring		Elimination of Hazards	
Internal or Provisional OEL	AVAILABILITY of TOXICOLOGICAL DATA	Monitoring	CERTAINTY of EXPOSURE JUDGMENT	Engineering Controls	EFFECTIVENESS & RELIABILITY
Working OEL / Hazard Banding		Modeling		Administrative Controls	
		Qualitative		PPE	
No OEL		**No Assessment**		**No Control**	

Less Robust

OVERVIEW OF OCCUPATIONAL EXPOSURE ASSESSMENT PGP

KEY CONTENT (1/2):

PGP Section	Selected Key Content
Scope & Objectives	• Assess and control all chemical, physical and biological exposures for all workers across all workdays
Program Management	• Written program • Under direction of an industrial hygienist experienced and trained in exposure assessment
Basic Characterization	• Critical information for characterizing exposures is documented for the workplace
Occupational Exposure Limits	• Authoritative or internal OELs are used for exposure judgments • Regulatory OELs are used if lower than authoritative or internal OELs
SEGs	• The workforce is stratified into similar exposure groups (SEG).
Exposure Judgments	• Exposure are acceptable if the 95th percentile is less than the OEL with 70% confidence (95% confidence best practice) • An AIHA Exposure Category (EC) and certainty rating are selected for each air contaminant and noise SEG • The exposure profile for each SEG is judged acceptable or unacceptable

OVERVIEW OF OCCUPATIONAL EXPOSURE ASSESSMENT PGP

KEY CONTENT (2/2):

PGP Section	Selected Key Content
Monitoring Practices	• 3+ baseline samples are collected for each SEG initially rated EC of 2 or 3 • Baseline sample data are analyzed using statistics to update the exposure category and the certainty rating • 3+ additional baseline samples are collected for SEGs with updated EC of 2 or 3 having low or medium certainty
Non-recurring Ops	• Non-recurring operations are anticipated, prospectively assessed, and controlled
Health Hazard Controls	• Initially, SEGs judged unacceptable are quickly controlled • Enhanced permanent controls (higher on the hierarchy) are sought in a prioritized manner
Med. Surveillance	• Med. surveillance is provided to workers in EC 3 and 4 where protocols are available
Com. & Training	• Findings and recommendations are reported in an effective and timely fashion
Reassessments	• Management of change procedures are established to provide notification of newly planned changes in the workplace, workforce, or environmental agents
Standard Controls	• Standard control approaches are considered in the exposure assessment process
Perf. Meas.	• Performance measures are identified, tracked, and communicated to stakeholders
Recordkeeping	• Exposure assessment records are maintained indefinitely

OCCUPATIONAL EXPOSURE ASSESSMENT PGP

ADDITIONAL DETAIL

PGP Section	Selected Key Content
Basic Characterization	• Needed to apply qualitative and quantitative tools. • Establishes Priorities for Further Assessment. • Aids in Controls Development. • Chemical/physical agents • Health effects and OELs • Work force organization • Processes contributing to exposure • Process conditions

OCCUPATIONAL EXPOSURE ASSESSMENT PGP

ADDITIONAL DETAIL

PGP Section	Selected Key Content
SEGs	• A similar exposure group (SEG) is workers having the same exposure profile for an agent • One or a few exposures characterize the exposure of everyone in that group. • Workers in an SEG may be exposed to multiple environmental agents. • It may be necessary to establish subgroups (separate SEGs) within a larger group. • Qualitative approach. Where exposure profiles are similar: Operations, Jobs (tasks), SEG. • Quantitative approach – SEGs based on the statistical analysis of the exposure data. • SEGs with a GSD for exposure data of 3 or greater should be reviewed.

OCCUPATIONAL EXPOSURE ASSESSMENT PGP

ADDITIONAL DETAIL

Table 7.3 – Manufacturing Plant Prioritization for Information Gathering.

SEG ID	Process	Job	Task	Agent	Quantity	Duration/ Frequency	Manual vs. Automated Operation	PPE	Engineering Controls	Exposure Rating	Basis for ER	OEL	Exposure Judgment	Health Effects Rating	Basis for HER	Health Risk Rating	Uncertainty Rating	Info Gather Priority Rating	Information Needed	Actions to be Taken
A	Coil Coating	Coil feed operator	General	Noise	NA	7.5 hours, 5 days/week	Automated	Ear plugs	Partial enclosure	3	Screening measurements (82-85 dB)	85 dBA – 8 hr TWA	Acceptable	3	Hearing loss	9	1	9	Noise dosimetry	Noise dosimetry to validate levels
B	Coil Coating	Coil feed operator	General	2-butoxy-ethanol	2500 lb/ shift	7.5 hours, 5 days/week	Manual	Nitrile gloves	Local exhaust vent	2	Modeling	25 ppm – 8 hr TWA, skin	Uncertain	2	Damage to red blood cells	4	2	8	Air and/or biological monitoring data	Air and/or biological monitoring
C	Coil Coating	Coil feed operator	Cleanup	MIBK	5 lb/shift	15 minutes, 5 days/week	Manual	Nitrile gloves, OV resp	General dilution vent	3	Personal monitoring data	75 ppm – STEL	Acceptable	2	URT irritation; dizziness	6	1	6	None	None
D	Coil Coating	Coil feed operator	Cleanup	Cyclohexanone	5 lb/shift	15 minutes, 5 days/week	Manual	Nitrile gloves, OV resp	General dilution vent	3	Exposure data from other agent	35 ppm – STEL, skin	Acceptable	1	URT irritation	3	1	3	None	None
E	Coil Coating	Discharge operator	General	Noise	NA	7.5 hours, 5 days/week	NA	Ear plugs	Partial enclosure	3	Screening measurements (82-85 dB)	85 dBA – 8 hr TWA	Acceptable	3	Hearing loss	9	1	9	Noise dosimetry	Noise dosimetry to validate levels
F	Coil Coating	Discharge operator	General	2-butoxy-ethanol	2500 lb/ shift	7.5 hours, 5 days/week	Automated	Nitrile gloves	Local exhaust vent	2	Modeling	25 ppm – 8 hr TWA, skin	Uncertain	2	Damage to red blood cells	4	2	8	Air monitoring data	Air monitoring
G	Coil Coating	Discharge operator	QC	MIBK	20 lb/shift	15 minutes, 8X/shift	Manual	Nitrile gloves, OV resp	General dilution vent	4	Modeling	75 ppm – STEL	Unacceptable	2	URT irritation; dizziness	8	2	16	Air monitoring data	Engineering control/ possible airmon validation
H	Coil Coating	Discharge operator	Cleanup	MIBK	5 lb/shift	15 minutes, 5 days/week	Manual	Nitrile gloves, OV resp	General dilution vent	3	Personal monitoring data	75 ppm – STEL	Acceptable	2	URT irritation; dizziness	6	1	6	None	None

OCCUPATIONAL EXPOSURE ASSESSMENT PGP

ADDITIONAL DETAIL

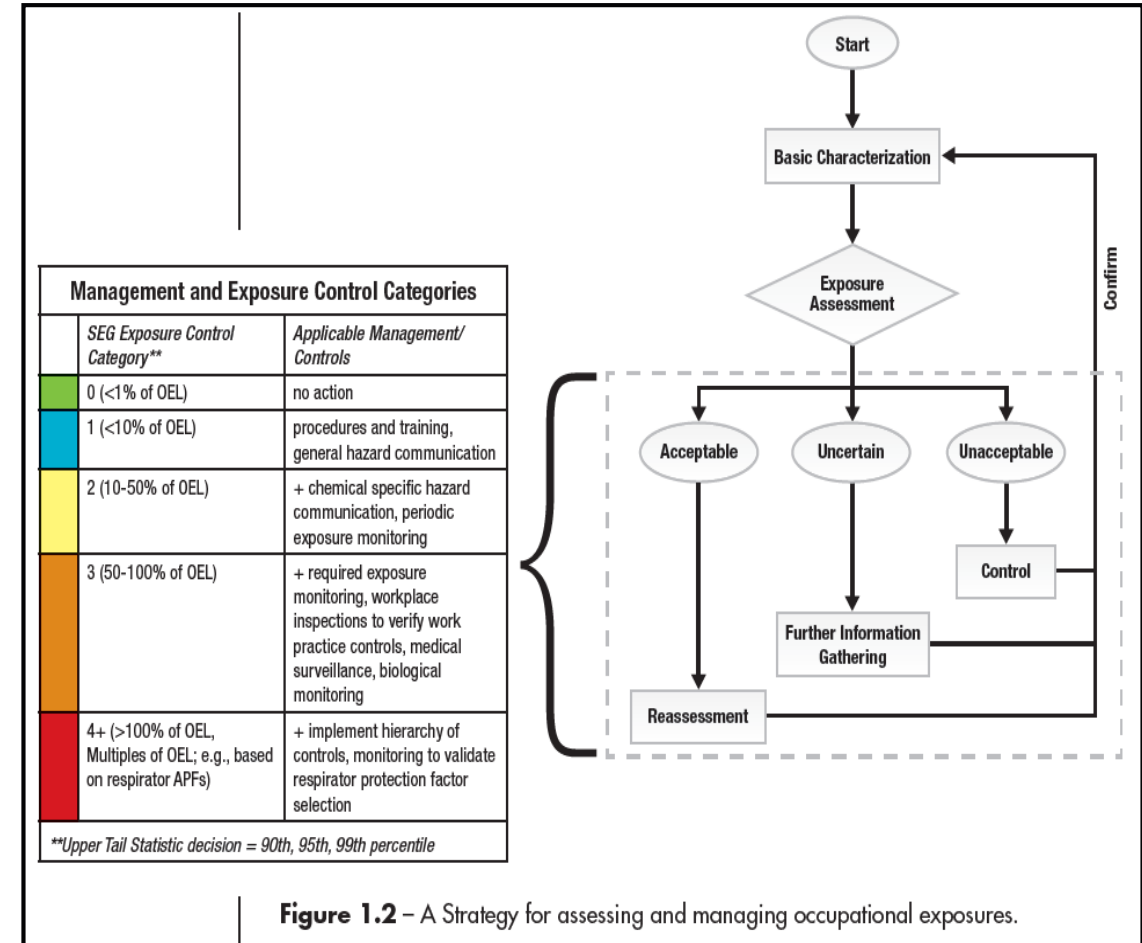| PGP Section	Selected Key Content
Exposure Judgments	• Accuracy • An AIHA Exposure Control Category (EC) and certainty rating are selected for each air contaminant and noise SEG • The exposure profile for each SEG is judged acceptable or unacceptable • A decision Statistic must be established to identify the threshold for acceptable exposure

OCCUPATIONAL EXPOSURE ASSESSMENT PGP

ADDITIONAL DETAIL

PGP Section	Selected Key Content
Monitoring Practices	• For SEGs initially rated as Exposure Category 2 [10 to 50% of OEL] or EC 3 [50% to 100% of OEL]; Collect 3 or more baseline samples. • The monitoring results are analyzed using traditional and/or Bayesian statistics and are used to update the SEG exposure category and the associated certainty rating. • Three or more additional samples are then collected for each SEG rated exposure category 2 or 3 with low or medium certainty. Implementing controls or improving existing controls is an alternative to collecting additional samples. • Exposures are judged acceptable if the estimated 95th percentile for the exposure profile is less than the OEL with at least 70% confidence (i.e., $UTL_{95/70} \leq OEL$, or BDA chart category 4 probability $\leq$ 30%).

Exposure Control Category**
0 (<1% of OEL)
1 (<10% of OEL)
2 (10-50% of OEL)
3 (50-100% of OEL)
4 (>100% of OEL)
Multiples of OEL (>500% of OEL or others based on respirator APF)

AIHA EXPOSURE CONTROL CATEGORIES

Increase Effectiveness and Efficiency

- Avoid diminishing returns from "over-refining" exposure estimates

- Streamline Documentation

- Facilitate Qualitative Exposure Judgements

- Drive consistent follow-up management and control activities which lead to consistent risk management.

Management and Exposure Control Categories

SEG Exposure Control Category**	Applicable Management/ Controls
0 (<1% of OEL)	no action
1 (<10% of OEL)	procedures and training, general hazard communication
2 (10-50% of OEL)	+ chemical specific hazard communication, periodic exposure monitoring
3 (50-100% of OEL)	+ required exposure monitoring, workplace inspections to verify work practice controls, medical surveillance, biological monitoring
4+ (>100% of OEL, Multiples of OEL; e.g., based on respirator APFs)	+ implement hierarchy of controls, monitoring to validate respirator protection factor selection

**Upper Tail Statistic decision = 90th, 95th, 99th percentile

Figure 1.2 – A Strategy for assessing and managing occupational exposures.

Improving Exposure Judgements, AIHA Webinar

Can be downloaded from:

https://www.aiha.org/get-involved/volunteer-groups/advancing-the-science-and-practice/principles-of-good-practice

Making Accurate Exposure Risk Decisions

Free Online Course
9 Contact hours

Instructors: Andrew D. Perkins MS, CIH, CSP, COHC, Jérôme Lavoué Ph.D., MS, Paul Hewett Ph.D, MS, CIH, FAIHA & John Mulhausen Ph.D., MS, CIH, CSP, FAIHA

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