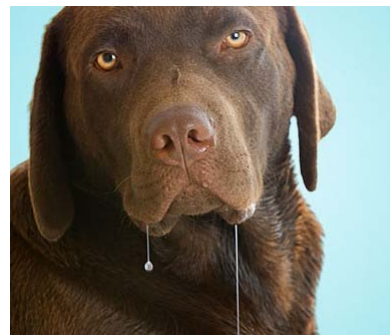


Outline

1. Intro and Goals
2. Brief History
3. What is an Occupational Exposure Limit (OEL)?
4. Who creates workplace exposure limits?
5. How are they created?
6. Where can you find OELs?
7. Application
8. Questions?

1. Audience Desires

- Why are you here?
- What do you want to get out of this session?
- What do you NOT want to hear about?
- Do you have a specific question you want answered?



<https://stevengoddard.wordpress.com/2012/11/24/pavlovs-dogs/>

2. OEL Brief History

	Arbeit noch ungesünder:	Arbeit noch möglich, aber Arbeitshilf:	Arbeit ungesund:
Ölöl	0,001—0,002%/se	0,002—0,003%/se	0,004%/se
Brom	0,001—0,002%/se	0,002—0,003%/se	0,004%/se
Jod	0,001%/se	0,0015—0,002%/se	0,003%/se
Ammoniak	0,1—0,2%/se	0,2—0,3%/se	0,5—1,0%/se
Kohlensäure	0,01%/se	0,01—0,05%/se	0,05—0,1%/se

Selbstverständlich muss ich mich eines Urteils darüber enthalten, in wie weit Arbeiter durch lange Gewöhnung höhere Werte zu ertragen im Stande sind, da mir in dieser Hinsicht keine Beobachtungen zu Gebote standen.

Matt, Ludwig. (1889) Experimentelle Beiträge zur Lehre von der einwirkung giftiger gas auf den menschen. Doctoral Dissertation, University of Wuzburg.

- 1921
- the US Bureau of Mines tables of exposure limits; 33 substances in the workplace
- 1941
- The Z-37 committee of National Standards Association [now ANSI] developed the first standard of 100 ppm for carbon monoxide. Prepared separate bulletins on 33 substances through 1974
- 1941
- An ACGIH subcommittee on Threshold Limits was formed under Committee on Technical Standards. In 1942 the subcommittee reported a table of 63 substances and their Maximum Acceptable Concentrations (MACs). 1948, the MACs were renamed **TLVs**. 714 TLVs as of 2008.
- 1970
- OSHA's limits established with the Occupational Safety and Health Act of 1970. The 500 **PELs** OSHA initially adopted were ACGIH's 1968 TLVs and ANSI's 1966, 1967, and 1968 limits [543 as of 2008]

OEL Brief History.....



- 1976
- AIHA formed a Workplace Environmental Exposure Limits (**WEEL**) committee in 1976 to address substances for which no recognized occupational exposure limits (OELs) had been developed. Currently 131.
- 1989
- OSHA lowered the existing **PELs** for 212 toxic air contaminants and established **PELs** for 164 previously unregulated air contaminants. [376 more protective, 1 less protective] Court ended this in 1992. 455 Limits as of 2008.
- 2014
- OSHA Publishes intent to review PEL setting process. Introduces Control Banding.

3. What is an Exposure Limit? - Really

Exposed Population

Exposure Scenario

Critical Adverse Effect to Prevent

Exposed Population

- Worker (_____)
- *Elderly & Very Young*
- *General Public*
- Emergency Personnel

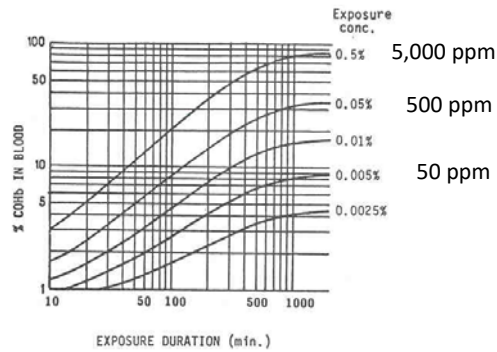


Exposure Scenario

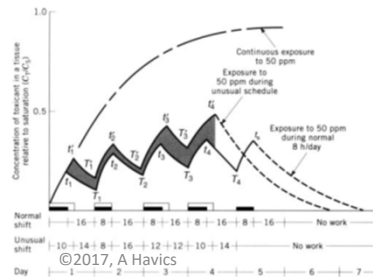
- **Time Period (Duration)**
 - Very Short Term [acute] (10-30 min)
 - Short Term (8 Hour work day)
 - *Moderate Length (1 month-3 years)*
- **Frequency**
 - Once per day
 - Multiple times per day
 - 250 days/year
 - 40-45 Years in a working lifetime
- **Summary**
 - _____
 - _____
 - _____
 - _____

Why Exposure Scenario Matters

- CO
- Peak Values
- Recovery

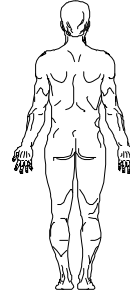


ACGIH, Carbon Monoxide BEI Documentation, 1996

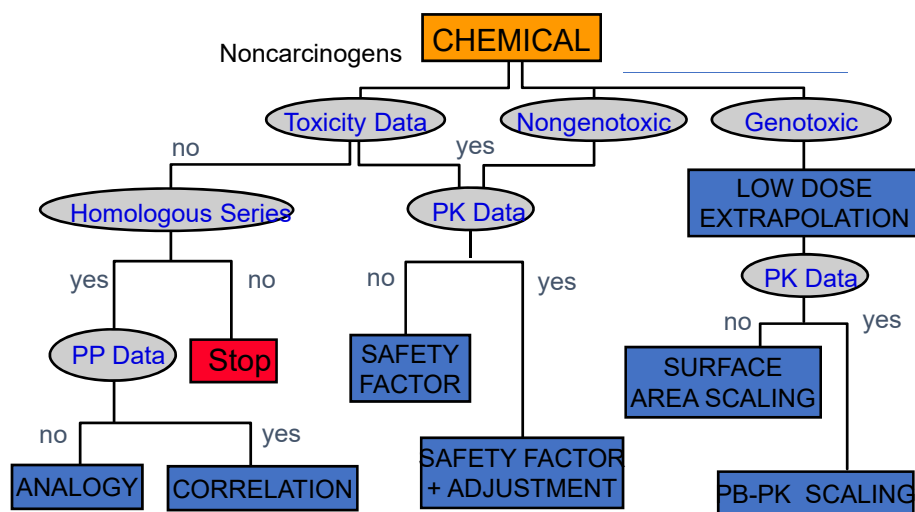


Critical Adverse Effect to Prevent

- Cancer
 - Genotoxic cancer
 - Non-genotoxic cancer
- Target Body Parts
 - Kidney, liver, lungs, heart, blood, etc.
- Nuisance or Transient
 - Odor, irritation, emetic, etc.



Don't panic



Definitions of Exposure Limits

- Permissible Exposure Limit (PEL) [Legally Binding]
 - An employee's exposure to any substance...shall not exceed the 8-hour TWA given for that substance for any 8-hour work shift of a 40-hour work week
- Threshold Limit Value (TLV) [Good IH Practice Guidance]
 - TLVs refer to airborne concentrations of chemicals substances and represent conditions under which it is believed that *nearly all* workers may be repeatedly exposed, day after day, over a working lifetime without adverse effects
- Workplace Environmental Exposure Level (WEEL) [Good IH Practice Guidance]
 - See TLV
- Recommended Exposure level (REL) [Best Practice]
 - Occupational exposure limits recommended by NIOSH as being protective of worker health and safety over a working lifetime. This limit is frequently expressed as a time-weighted average (TWA) exposure for up to 10 hr/day during a 40-hr workweek

Exposure Scenarios for Workplace OELs

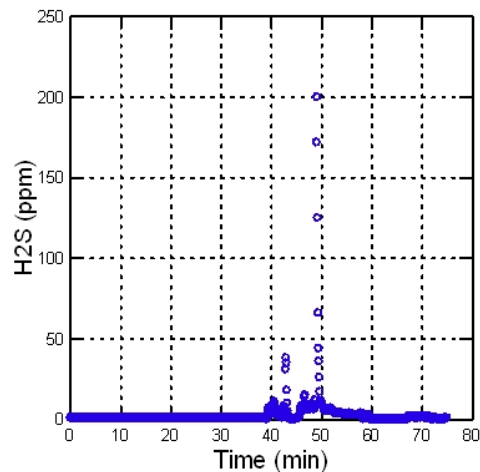
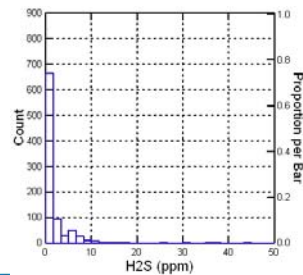
- 8-Hour Time Weighted Average (TWA)
 - An average exposure over an 8-hr workday weighted by time of exposure
- Short Term Exposure Limit (STEL)
 - A STEL is defined as a _____TWA exposure which should not be exceeded any time during the workday
- Excursion (OSHA)
 - An Excursion is defined as a 15-minute or 30-minute TWA exposure which should not be exceeded any time during the workday

Exposure Scenarios for Workplace OELs

- Ceiling Limit
 - Exposure shall at no time exceed the exposure limit given for that substance. If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute time weighted average exposure which shall not be exceeded at any time during the working day
- Peak Limit
 - Only for a maximum period of 5-30 min above the Ceiling Limit but below the Peak [per Table Z-2]
- Action Limit
 - A trigger level used to initiate requirements for periodic monitoring, medical surveillance, training, labels and other provisions (8-hour TWA). Usually _____ of the PEL-TWA.

Limitations of Ceiling Limit

- In theory, you can have issues:
- Hydrogen Sulfide
- 5 Second Measurements from 0-200 ppm



Hydrogen Sulfide – A Health Threat?

Measured Maximum TWA (ppm)	Time Period for TWA (min)	Limit (ppm)
5.7	30	100 IDLH
10.2	15	20 Ceiling
12.9	10	50 Peak
200	0.083 (5 sec)	?

Time Weighted Average (TWA)

1 pill/hr for 1 hour
3 pills/hr for 2 hours
6 pills/hr for 4 hours
5 pills/hr for 1 hour

~~14 pills/hr in 8 hours
14/8 = 1.75 pills/hr~~

$$TWA = \frac{\sum_{i=1}^n (C_i)(t_i)}{\sum_{i=1}^n t_i}$$

$$TWA = \frac{[(C_1)(t_1)] + [(C_2)(t_2)] + [(C_3)(t_3)] + [(C_n)(t_n)]}{\dots}$$

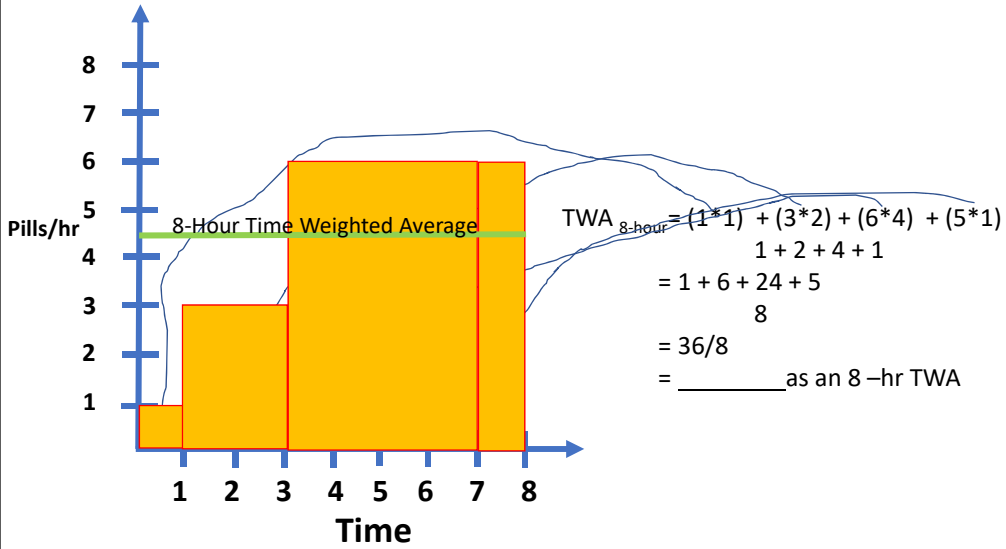
MATH

C_1 = Concentration for Time period 1
 C_2 = Concentration for Time period 2
 C_3 = Concentration for Time period 3
 C_n = Concentration for Last Time period

Mental Abuse To Human
 t_1 = Time period 1
 t_2 = Time period 2
 t_3 = Time period 3
 t_n = Last Time period

$$\begin{aligned} TWA_{8\text{-hour}} &= (1*1) + (3*2) + (6*4) + (5*1) \\ &= \frac{1 + 2 + 4 + 1}{8} \\ &= \frac{1 + 6 + 24 + 5}{8} \\ &= \frac{36}{8} \\ &= 4.5 \text{ as an 8-hr TWA} \end{aligned}$$

Time Weighted Average (TWA)



Action & Excursion Limit

Chemical	PEL-TWA (8 hour)	Action Level (8 hour)	STEL (15 Min)	Excursion
Asbestos	0.1 f/cc	0.1 f/cc withdrawn when 0.2 f/cc PEL-TWA was reduced to 0.1 f/cc		1 f/cc 30 min
Ethylene Oxide (EtO)	1 ppm	0.5 ppm		5 ppm 15 min
Arsenic	10 µg/m ³	5 µg/m ³		
Lead	50 µg/m ³	30 µg/m ³		
Cadmium	5.0 µg/m ³	2.5 µg/m ³		
Benzene	1.0 ppm	0.5 ppm	5 ppm	
Cotton Dust	200/500/750 µg/m ³	100/250/375 µg/m ³		
Acrylonitrile	2 ppm	1 ppm	10 ppm (listed as C)	
Formaldehyde	0.75 ppm	0.5 ppm	2 ppm	
Methylenedianiline (MDA)	10 ppb	5 ppb	100 ppb	
Crystalline Silica	50 µg/m ³	25 µg/m ³	Not IN Effect YET	

4. Who creates workplace exposure limits?

- Occupational Safety & Health Administration (OSHA)
- National Institute of Occupational Safety & Health (NIOSH)
- Workplace Exposure Level Committee (AIHA-TERA-Univ Cinci)
- American Conference of Governmental Industrial Hygienists (ACGIH)
- _____.
- National Academy of Sciences (NAS)
- _____.

More Acronyms?

- NCEL
 - _____.
 - _____ TSCA 5e
- DNEL
 - Derived no-effect level
 - EU REACH Program
- ERPG
 - Emergency Response Planning Guidelines
 - AIHA
- AEGL
 - Acute Exposure Guideline Level
 - EPA & NAS
- IDLH
 - Immediately Dangerous to Life & Health
 - NIOSH



Derivation of Immediately Dangerous to Life or Health (IDLH) Values



5. How are they created?

- Analogy
- Correlation
- Low Dose Extrapolation
- Margin of Safety Approach
 - Direct NOAEL/LOAEL Approach
 - Benchmark Dose (BMD)

Analogy To Acetic Acid

		<u>PEL (ppm)</u>
$\begin{array}{c} \text{O} \\ \\ \text{H}_3\text{C} - \text{C} - \text{OH} \end{array}$	Acetic Acid	10
$\begin{array}{c} \text{O} \\ \\ \text{H}_3\text{C} - \text{CH}_2 - \text{C} - \text{OH} \end{array}$	Propionic Acid	10
$\begin{array}{c} \text{O} \\ \\ \text{H}_2\text{C} = \text{C} - \text{C} - \text{OH} \end{array}$	Acrylic Acid	10*
		*Vacated

Correlation

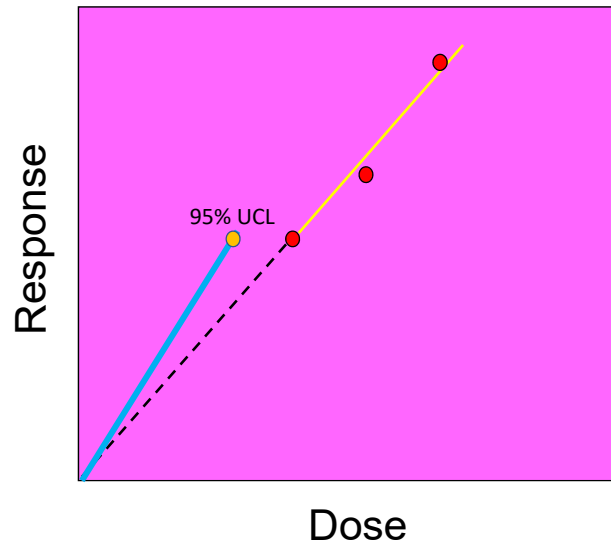
- Compares specific quantifiable property related to potency
- $OEL = (PP_a / PP_b) \times OEL_b$
 - PP = physicochemical property
 - PP must be established as a valid predictor of the biological effect upon which the OEL is based

Correlation



- OEL for propionic acid based on irritation potential
 - Irritation potential = $f(\text{acidity}) = f(pK_a)$
 - Bromopropionic acid = 70x more acidic than propionic acid
 - $OEL_{\text{bromopropionic acid}} = TLV_{\text{propionic acid}} / 70$
 - $OEL_{\text{bromopropionic acid}} = 10 \text{ ppm} / 70$
 - $OEL_{\text{bromopropionic acid}} = 0.14 \text{ ppm}$
 - According to methods developed by Alarie, for sensory irritants:
 - $TLV = f(RD_{50}) = 0.03 (RD_{50})$ or $0.01(RD_{50})$
 - RD_{50} for Hydrogen Chloride = 309 ppm
 - OEL = 3 ppm to 9 ppm; PEL is 5 ppm

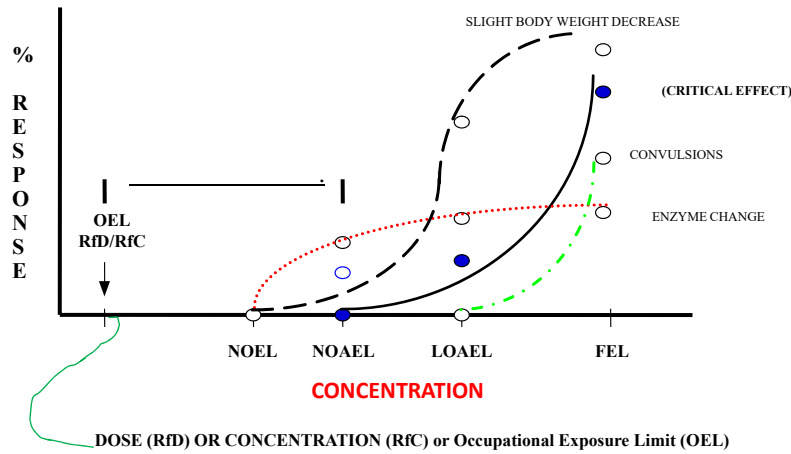
Low Dose Extrapolation



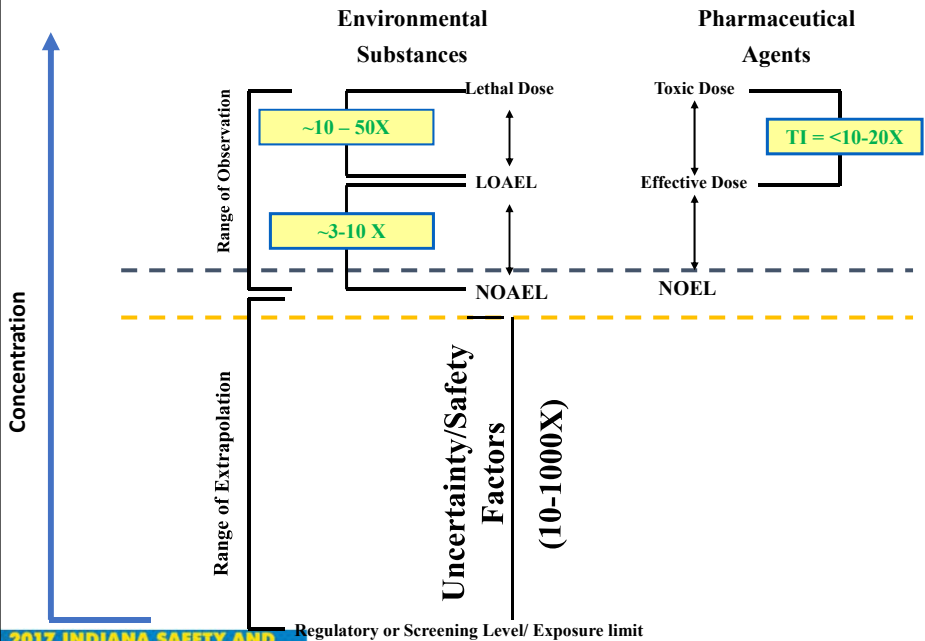
Margin of Safety Approach (MOS)

- Derive an acceptable human exposure level by applying safety/uncertainty factors to the no-observed-adverse-effect level (NOAEL) or benchmark dose (BMD)

Characterizing Non-Cancer Hazards In Risk Assessments (threshold effect)



Environmental and Clinical Perspectives



Margin of Safety Approach

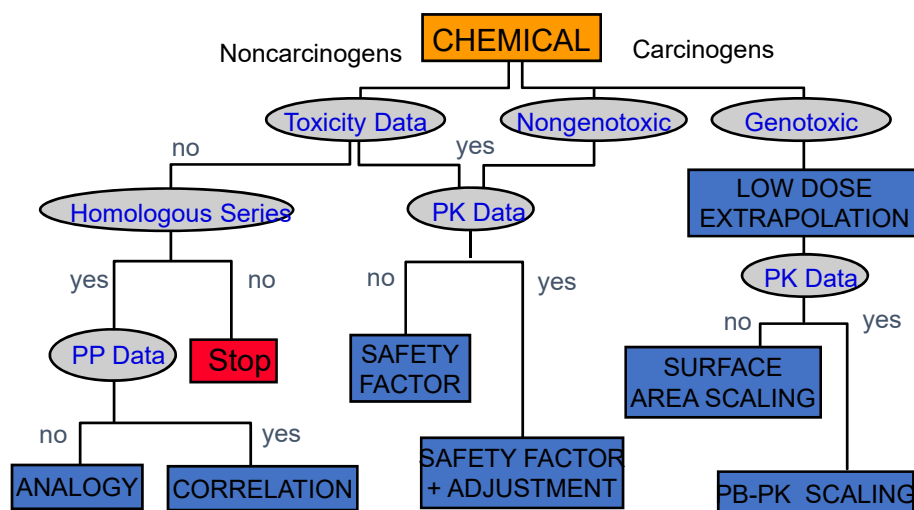
$$\text{OEL (mg/m}^3\text{)} = \frac{(\text{NO Effect Level}) \times (\text{Body Weight})}{(\text{Uncertainty \& Safety Factor}) (\text{Volume Air})}$$

- **Interindividual Variability** 1-10
- **Interspecies Extrapolation** 1-10
- _____ 1-10
- **Route-to-Route Extrapolation** 0.01-100
- **Modifying Factor** >0-10



Arkansas Times

The Method of Choice



6. Where can you find OELs?

- OSHA 29 CFR 1910.1000
 - <https://www.osha.gov/dsg/annotated-pels/>
 - Online
- WEELS
 - <http://www.tera.org/OARS/WEEL.html>
 - Online, PDF, Excel
- ACGIH TLVs
 - <http://www.acgih.org/forms/store/ProductFormPublic/2017-tlvs-and-beis>
 - PDF & Hardcopy for Purchase
- NIOSH RELs
 - <https://www.cdc.gov/niosh/npg/>
 - Online, PDF, Mobile app

7. Application

- Silica

TABLE Z-3—MINERAL DUSTS

Substance	mppt ^a	mg/m ³
Silica:		
Crystalline		
Quartz (Respirable)	250 ^b	10 mg/m ³ ^a
	%SiO ₂ +5	% SiO ₂ + 2
Quartz (Total Dust)		30 mg/m ³
		% SiO ₂ + 2
Cristobalite: Use ½ the value calculated from the count or mass formulae for quartz Tridymite: Use ½ the value calculated from the formulae for quartz		
Amorphous, including natural diatomaceous earth	20	80 mg/m ³
		%SiO ₂

^aCalculate (free than 10' crystalline silica)

- Current ACGIH TLV 50 ug/m³ as an 8-hr TWA
- Proposed OSHA PEL of _____ as an 8-hr TWA
 - “quartz, cristobalite, and/or tridymite”

Asbestos

Is the Exposure OK?

- _____ :

- OSHA PEL = 0.1 f/cc 8-Hr
- ACGIH TLV 0.1 f/cc 8-hr

- _____ :

⋮

Sample #	Concentration	Time (min)
1	1.2 f/cc	30
2	0.01 f/cc	240
3	0.05 f/cc	120
4	0.02 f/cc	120

Tony's Interpretation

Category	Quality	95% Upper Limit Range	Chance of Trouble with OSHA
0	Very Good	0-1% of OEL	Fat Chance
1	Good	>1-10% of OEL	Very Unlikely
2	OK	>10-50% of OEL	Unlikely
3	Marginal	>50-100% of OEL	Possible, on a rare occasion
4	Bad	> 100% OEL	Very Likely

Modified from:
Hewett, Rating Exposure Control Using Bayesian Decision Analysis, JOEH, 3, 10, 568-581, 2006

