Chapter 2: Toxicology

Considers worker exposures

Definitions

Toxicology: - entry of toxicants into organism
- elimination from organism
- effects on organism

Quantitative

Industrial hygiene: prevention or reduction of entry

Toxicant - chemical agents
- physical agents: particulates < 5 µm, noise, radiation

Toxicity: property related to effect on organism
Problem: organisms respond via a distribution of effects

Toxic hazard: likelihood of damage based on exposure
reduction by appropriate techniques

Entry Routes for Toxicants

	ROUTE	ENTRY	CONTROL
	Ingestion	Mouth, stomach	Rules on eating, drinking, smoking
*	Inhalation	Mouth, nose	Ventilation, hoods, protection equipment
	Injection	Cuts in skin	Protective clothing
*	Dermal Absorption	Skin	Protective clothing

* industrially most significant

Routes and elimination

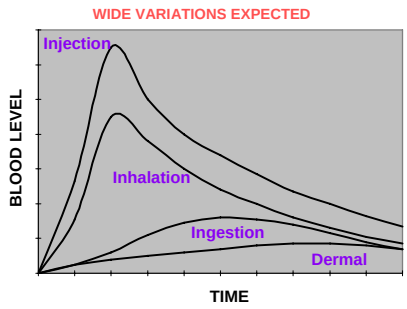
DIGESTIVE TRACK → BLOOD → TARGET ORGAN

LIVER → KIDNEYS / LUNGS

EXCRETION	kidneys (urine), liver (bile), lungs, skin
DETOXIFICATION	liver
STORAGE	fat tissue
INACTIVATION	

Figure 2-1

Toxic blood levels



Toxicology Experiment with Rabbits!

Start with 50 rabbits.

Expose each to a fixed concentration.

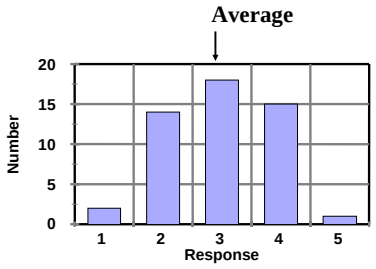
Get a variety of responses.

Determine Response Curve

Response		Number	Fraction
Least	1	2	0.04
	2	14	0.28
	3	18	0.36
	4	15	0.30
Worst	5	1	0.02
		50	1.00

Average = (1x2+2x14+3x18+4x15+5x1)/50 = 149/50
= 2.98

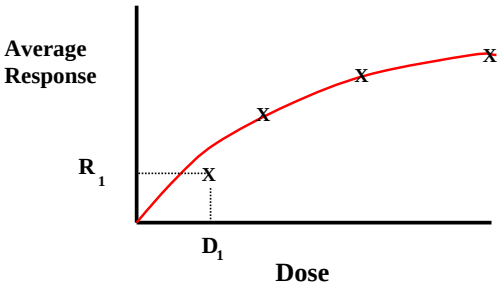
Plot Bar Chart



Repeat experiment at different doses.

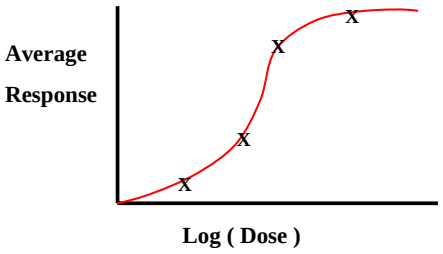
Dose	Average Response
D_1	R_1 = 2.98
D_2	R_2
D_3	R_3
D_4	R_4

Plot Response vs. Dose



This form not very useful, particularly at low doses.

Take the log of the dose.

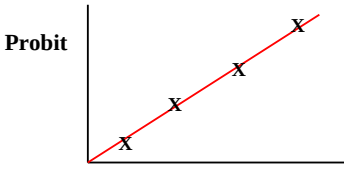


Get S-shaped curve - better at low dose values

Transform into Probit

Change S-shape into straight line using a mathematical transformation called a probit.

See Table 2-4 in text for numerical conversion.



Probit Equations

Using probits, most response vs. dose curves can be represented in the form:

$$Y = k_1 + k_2 \ln (V)$$

where Y = Probit variable

k_1, k_2 are constants

V = causitive variable

See Table 2-5 for a list of probit equations for toxic exposures, fires and explosions.

Conversion from Probit to %

$$P = 50\left[1 + \frac{Y-5}{|Y-5|} erf\left(\frac{|Y-5|}{\sqrt{2}}\right)\right]$$

P = Percentage

Y = probit

erf = error function (available on spreadsheet)

This is very useful for spreadsheet calculations!

Threshold Limit Values

THRESHOLD DOSE: NO DETECTABLE EFFECT

Threshold Limit Value TLV: worker's lifetime
This is for 8 hours per day, 40 hours per week.
NOT CONTINUOUS EXPOSURE!

TLV - TWA *	**Time weighed average**
TLV - STEL	**Short term exposure limit**
TLV - C	**Ceiling limit**

See Table 2-7 for detailed definitions of these.

See Table 2-8 for specific values for a number of chemicals. More values are available for TWAs than for STEL or C.

Threshold Limit Values - 2

Published by ACGIH: American Conference of Governmental Industrial Hygienists, a professional organization without legal authority.

Cannot be used as indication of relative toxicity.

Cannot be used for air pollution exposures.

Some toxicants have zero thresholds

TLV – Example Values Table 2-8

Acetone	**750 ppm**
Ammonia	**25 ppm**
CO	**25 ppm**
Chlorine	**0.5 ppm**
Gasoline	**300 ppm**
Hexane	**50 ppm**
Phosgene	**0.1 ppm**

For flammables, TLV is ¼ of lower flammable limit.

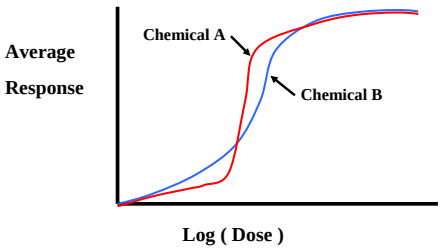
Conversion from mg/m³ to ppm

$$\text{ppm} = \left(\frac{22.4}{M}\right)\left(\frac{T}{273}\right)\left(\frac{1}{P}\right)\left(\text{mg/m}^3\right) = 0.08205\left(\frac{T}{PM}\right)\left(\text{mg/m}^3\right)$$

Equation (2-7)

For liquid mixtures ppm = mg/m³, but this is not true for vapors!

Problem with Relative Toxicity



PEL - Permissible Exposure Level

Published by OSHA, and have legal authority.

Defined the same as TLV.

Most PELs are same as TLVs.

Not updated as regularly as TLVs.

Most companies use lowest of the two values.

For some chemicals, i.e. benzene, vinyl chloride, a specific OSHA regulation has been published. Each regulation is unique, but most require EXPLICIT data that workers are not exposed.

See OSHA.gov web site for regulations.