



Statistics and Representative measurements

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Statistics & Representative measurements

- Statistics is a scientific trick
 - Garbage in (delivered by you!!) => garbage out
- Collecting representative measurements is an art
 - Skills
 - Experience
 - Observation
 - Analyse
 - Communication

Different scenarios

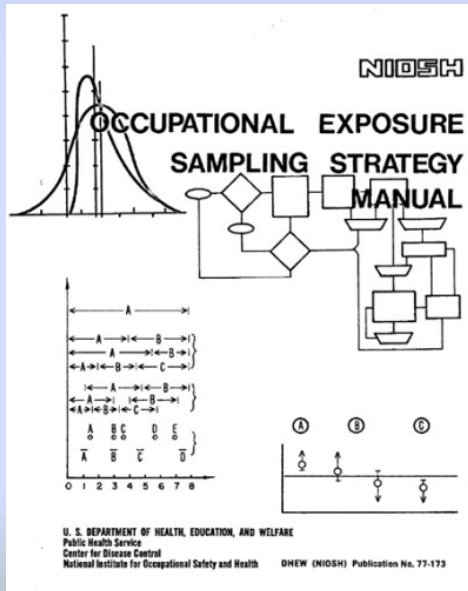
Representative measurements for OELV testing should reflect:

1. SEG exposure variability in space and time
2. the legal limit reference period specific exposure of an individual worker
3. Worst case
4. SEG long-term average exposure level
5. Task specific workers safe exposure

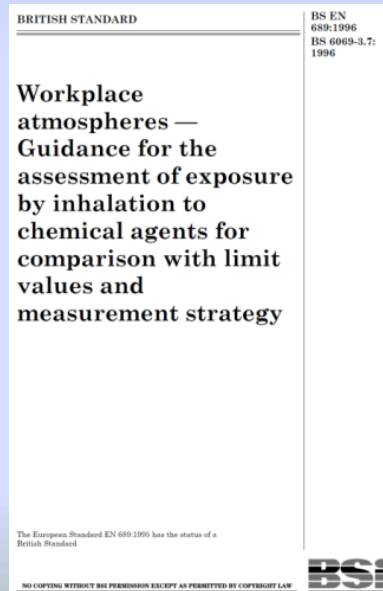


Struggling with representativeness, small sample sizes and exposure variability

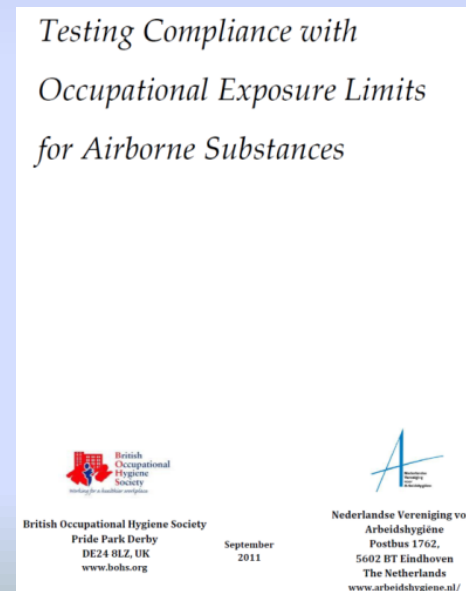
1977



1995



2011



2016

prEN 689
Next speaker
Roger Grosjean

EN 689 Screenings test

Decision 5.5.2	Compliance	reassess ment	Non- compliance
Sample size N	All outcome < $f \cdot \text{OELV}$	Otherwise	Outcome > OELV
3	$f=0.1$		≥ 1
4	$f=0.15$		
5	$f=0.2$		

Evidence based for $\text{GSD} \leq 3$: INRS (2005) ND2231



Exercise 1

- Exposure profile/scenario: Operator filling bags
- 3 gravimetric 8 hr PAS measurements : 0.45, 0.4 and 0.45 mg/m³
- $CV_t=25\%$ (EN 482, coefficient of variation)
- OELV: 5 mg inhalable/m³

• Compliance



or



?

• Representative measurements?

• GSD=1.07 !





– small sample error, autocorrelation

– evaluate SEG/sampling plan => resample $N \geq 3$

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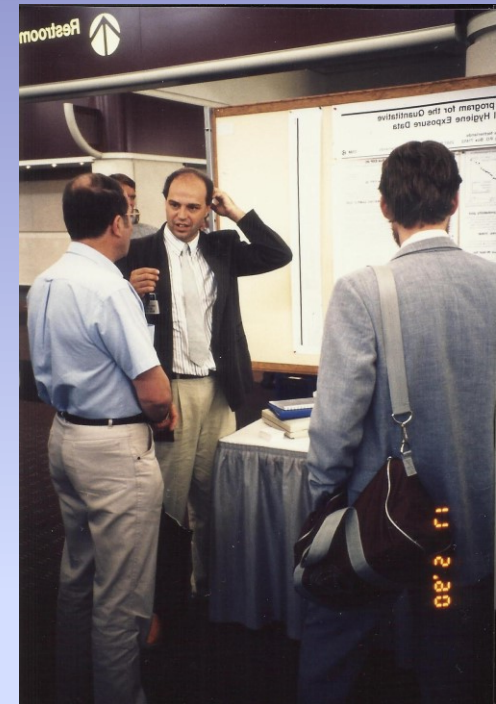
Excercise 2



- Three solvent measurements 0.01; 0.3 and 9.9 ppm
- Professional spay painting
- Solvent OELV: 100 ppm
- Compliance  or  ?
- Exposure range of 3 orders of magnitude (GSD=31)
- Representative for professional spay painting?
 - Read across (next slide)
 - If no, then improve SEG/sampling => resampling $N \geq 3$
 - If yes, then (not in standard) => additional sampling up to $N \geq 6$

Painters GSD, read-across Annals 1985

Type of object	Number of painters*	Types of paint	Remarks
1 Apartment building	6	Chlororubber paint	
2 Ambassador's house	4 H	Synthetic wall paint, prime colour varnish	
3 Telephone district centre	3 H	Alkyd resin, latex wall paint, synthetic wall paint	
4 Brewery	4	Synthetic wall paint, 2-component epoxy resin	
5 Furniture showroom	6 H	Alkyd resin	Spraying by 1 painter
6 Canteen	4	Structure wall paint, alkyd resin	Spraying by 1 painter assisted by 1 colleague
7 Room of regents in Lower House residence	4	Turpentine paint	Only 2 painters were sampled
8 Garage	5 H	Latex wall paint, synthetic wall paint, 2-component varnish	
9 Pumping station	4	Chlororubber paint	During only a few minutes were protective clothes with air refreshment worn
10 Laboratory	2 H	Synthetic wall paint	
11 Laboratory	3 H	Varnish, alkyd resin	
12 Distributing station	2	2-component polyurethane lacquer	Spray-painting was performed during several minutes



Painter group	Number of painters (n)	Tolerance factor k_7^*	Log normality P_t^\dagger	Geom. mean GM_{\ddagger}^{\ddagger} (mg m^{-3})	Geom. stand GSD_{\S}^{\S}
House painters	20	2.752	0.85	58.66	2.086
Total group	45	2.408	0.38	100.9	2.673
House painters	20	2.752	0.50	0.15	1.936
Total group	45	2.408	0.04**	0.28	2.648

Exposure variability

- Compare your GSD with the typical variability for the exposure profile tested:
 1. measurement series performed before
 2. GSDs reported in large databases like the French COLCHIS and the German MEGA
 3. literature
 4. Read across with comparable substances and workplaces

Initial Assessment – Testing Compliance with OELvs

- Statistical test : ≥ 6 results
 - The test shall measure, with at least 70% confidence, whether less than 5% of exposures in the SEG exceed the OELV
 - $C_{95\%,70\%} < \text{OELV}$ **Compliance**
 - $C_{95\%,70\%} > \text{OELV}$ **Non-Compliance**



Exercise 3



- ≥ 6 measurement in a clean room
- $GSD=2$
- $CV_t=5\%$
- $C_{95\%,70\%}<OELV$
- 5.5.3. Compliance!
- Is the GSD representative for clean room?
 - Evaluate controls \Rightarrow resampling $N \geq 3$
 - Evaluate between worker differences ($N \geq 2 \times 3$)

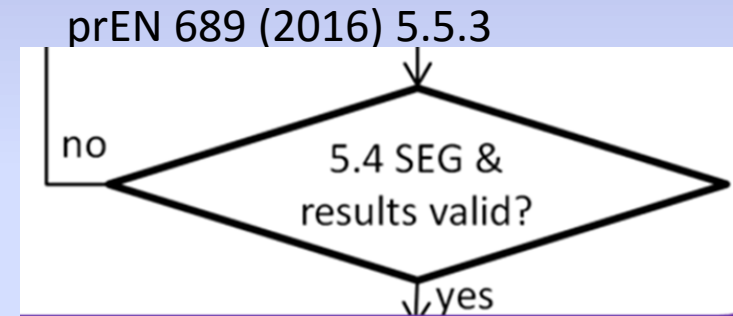
prEN 689 (2016) 5.5.3





Exercise 4

- ≥ 6 measurement outdoor painter, solvent exposure
- $GSD=1.4$
- $CV_t=5\%$
- $C_{95\%,70\%}<OELV$
- Compliance  or  ?



Is a $GSD=1.4$ representative for this exposure scenario?

- evaluate SEG & sampling plan

Exposure variability

- Underestimation of GSD's is caused by:
 - one day sampling.
 - small sample size
 - sloppy handling of non-detectables
 - autocorrelation (one outcome determines the next)
 - 2-decades analytical detection methods (like gravimetric dust and inorganic acid sampling)
 - EM in stead of PAS
- Use your expertise (and prEN 689 chapter 5.1 through 5.4)!
- For workplace $GSD \leq 3$, between-worker differences may become relevant: individual exposure testing

No two workers are exposed exactly the same

2011

Testing Compliance with Occupational Exposure Limits for Airborne Substances

Testing between worker
differences



British Occupational Hygiene Society
Pride Park Derby
DE24 8LZ, UK
www.bohs.org

September
2011

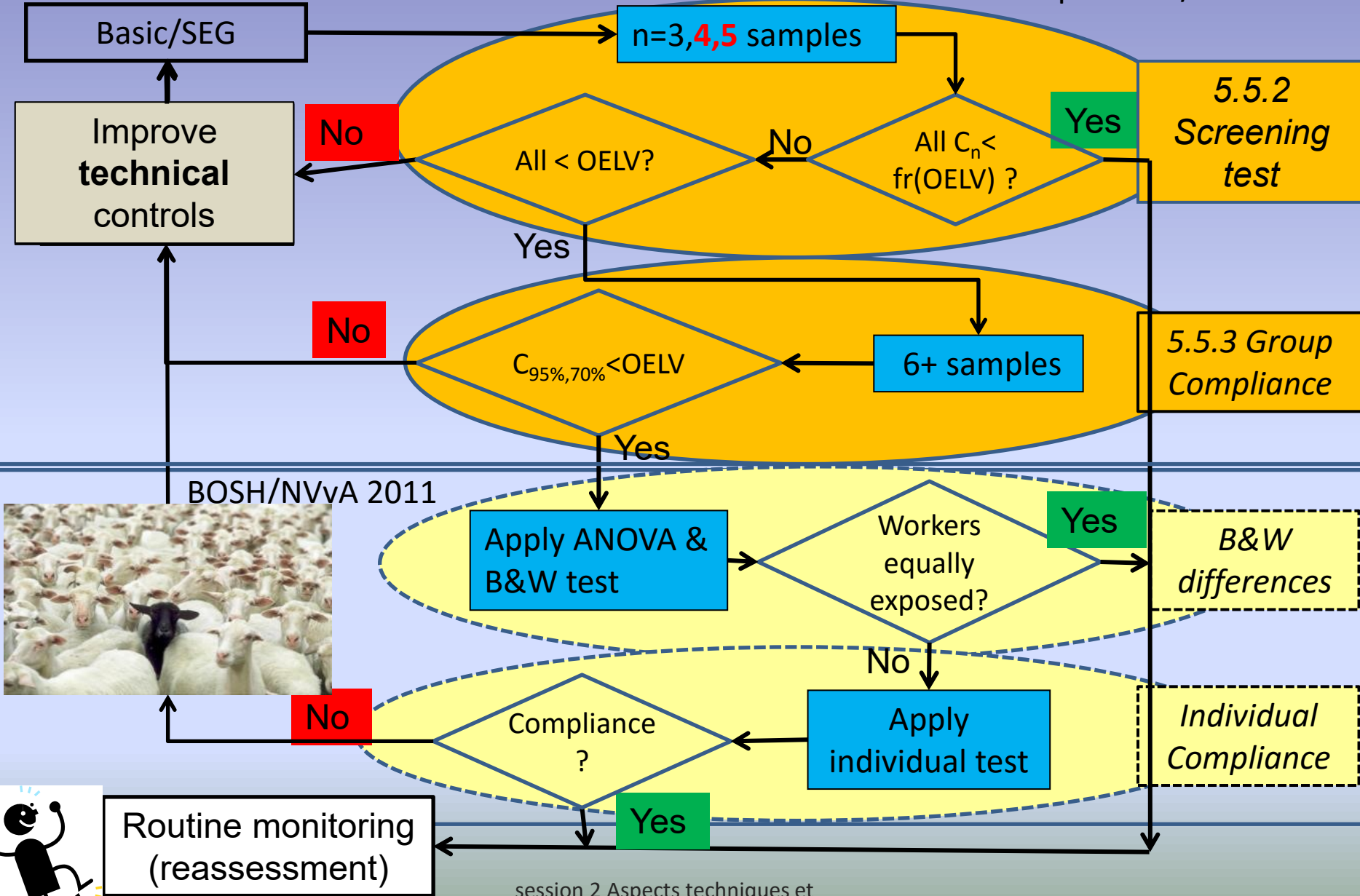


Nederlandse Vereniging voor
Arbeidshygiëne
Postbus 1762,
5602 BT Eindhoven
The Netherlands
www.arbeidshygiene.nl/

But are their
differences within
a well defined
exposure group
relevant ?

prEN 689/NVvA-BOHS testing scheme

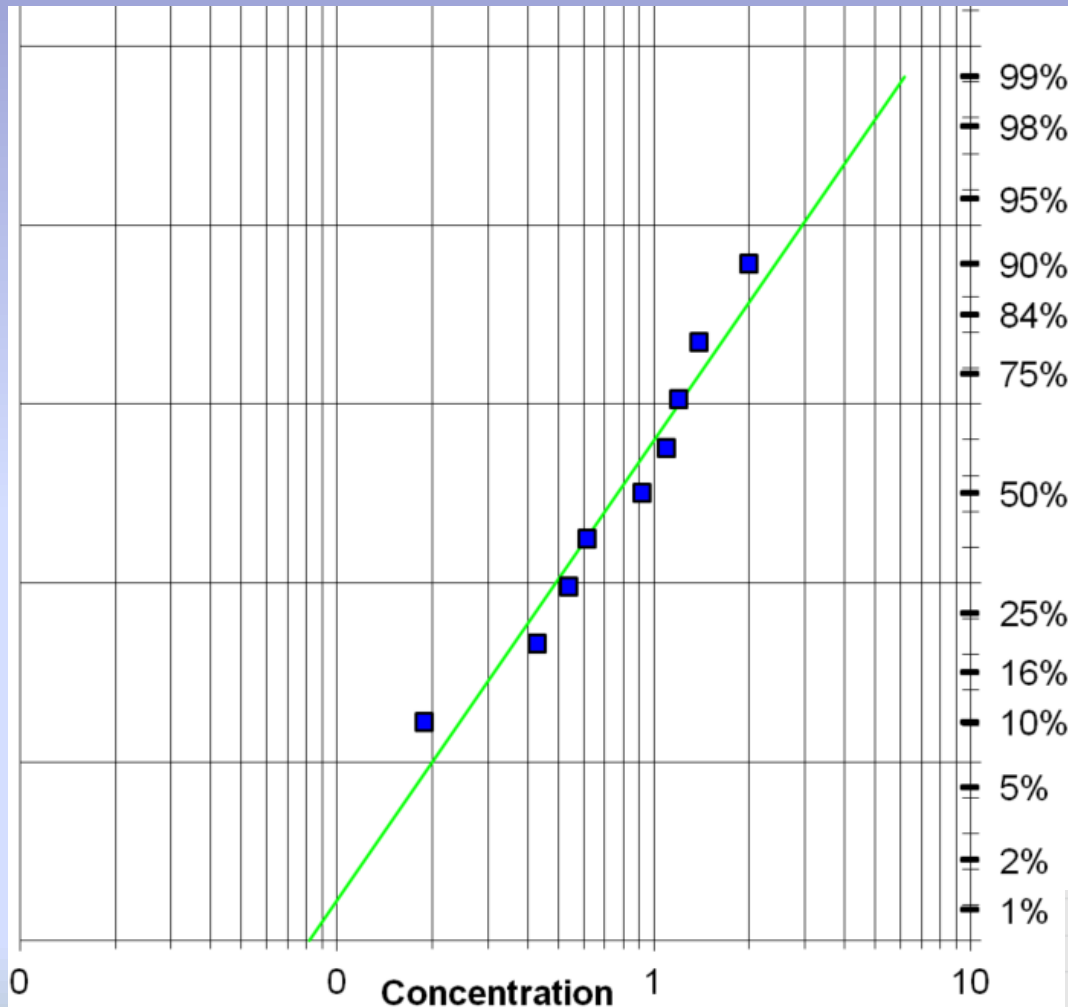
prEN689/BOHS-NVvA



Between Worker Variability in SEG

- Becomes apparent if long-term day-by-day $GSD < 3$
- Linked to well-controlled (“clean room”) or fix tasks exposure scenarios
- May stigmatize workers as “dirty”, incorrectly if individual sample size is small (< 6)

Lognormal probability Exercise 5



Example

Annex E , figure E.2

IH-Stat plot

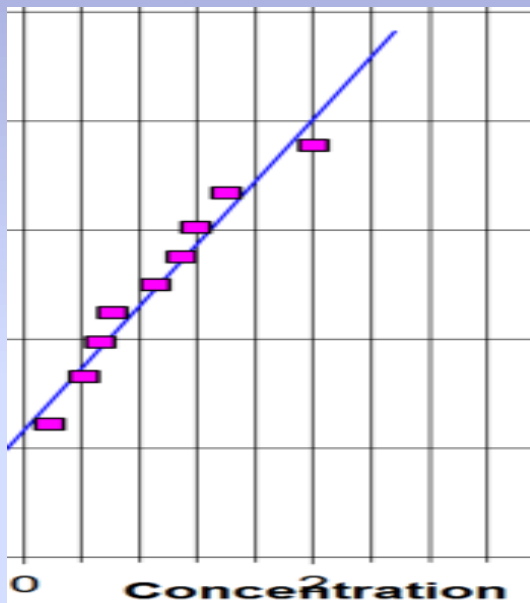
N=9 dust samples

Range .2 to 2 mg/m³

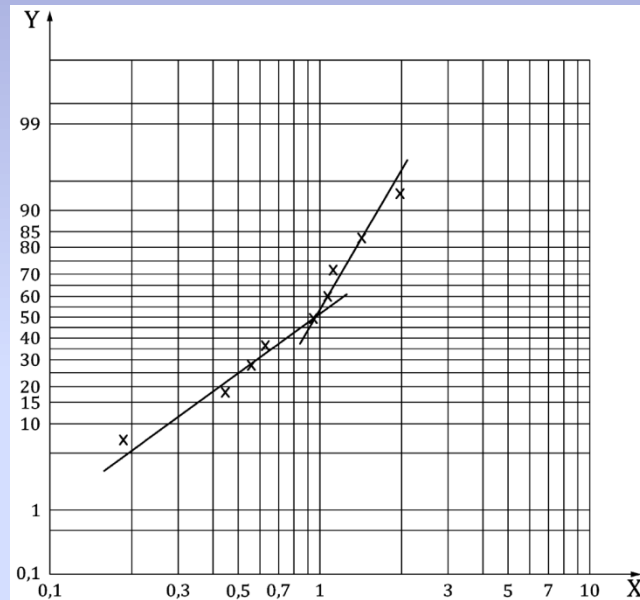
GSD=2.045

TEST FOR DISTRIBUTION FIT	
W-test of logtransformed data (LN)	0.958
Lognormal (a = 0.05)?	Yes
W-test of data	0.964
Normal (a = 0.05)?	Yes

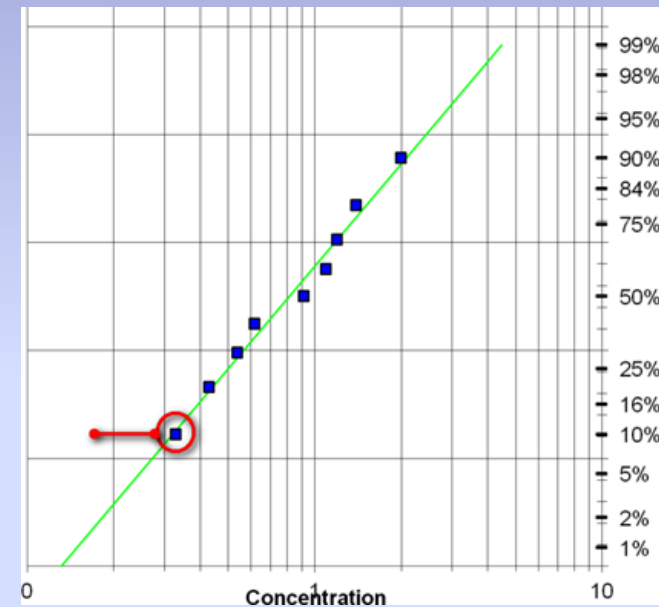
A little bit of lying with statistics



CVt Normal?



2 lognormal distributions?



one inaccurate low value?

Not the statistics, but the exposure determinants (5.1 through 5.3) will tell!

Become a representative measurement expert!
Let BW_stat do the statistics

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