AIHA's Exposure Assessment Strategies Symposium 2001

Panel discussion
Implementing quantitative exposure models
October 6, 2001, 2:15 pm – 2:45pm

Long-term exposure sampling at a Dutch (bio)chemical production site

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Long-term Exposure Sampling at a Dutch Chemical Production Site

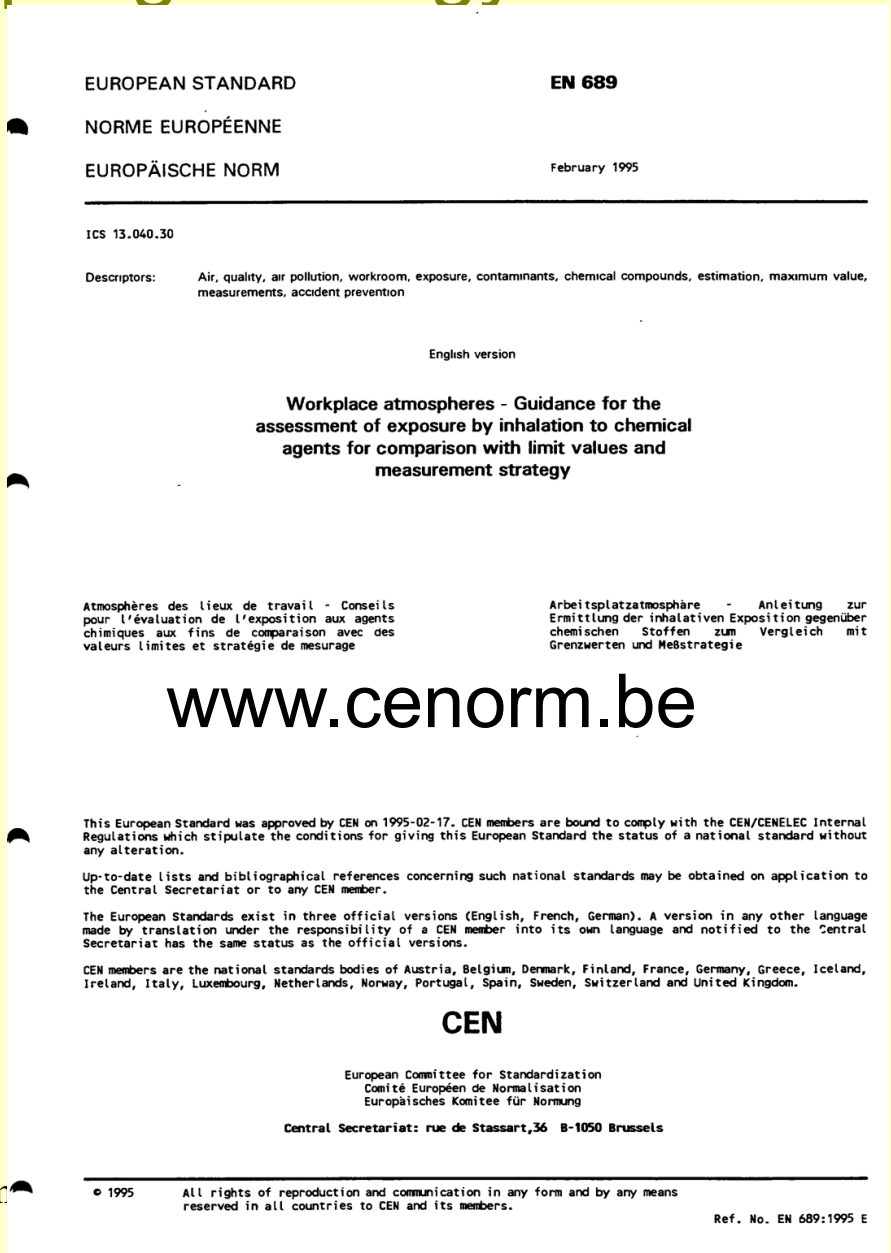
Presentation in three parts:

- EU/ CEN sampling strategy
- Controversies in quantitative evaluation
- Vinyl chloride example

EU/ CEN Sampling Strategy

Quantitative assessment

- Chapters 5.2 through 6
- Eight annexes A - G (informative, not part of the standard)



EUROPEAN STANDARD **EN 689**

NORME EUROPÉENNE

EUROPÄISCHE NORM February 1995

ICS 13.040.30

Descriptors: Air, quality, air pollution, workroom, exposure, contaminants, chemical compounds, estimation, maximum value, measurements, accident prevention

English version

Workplace atmospheres - Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy

Atmosphères des lieux de travail - Conseils pour l'évaluation de l'exposition aux agents chimiques aux fins de comparaison avec des valeurs limites et stratégie de mesurage

Arbeitsplatzatmosphäre - Anleitung zur Ermittlung der inhalativen Exposition gegenüber chemischen Stoffen zum Vergleich mit Grenzwerten und Meßstrategie

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart,36 B-1050 Brussels

Ref. No. EN 689:1995 E

CEN 689 Chapter 5.2 –5.5 Measurement Strategy

- Only when exposure is close to the limit
- Homogeneous Exposure Groups: $0.5<Am_i/Am_{heg}<2$
- Representative (job) and worst-case (task)
- Unsampled time
- Procedures (sampling, analytical)
- Mixtures

CEN 689 Chapter 6
Periodic Measurements

- Trends & long-term effective control,
- Statistical analysis (graphical)
- Intervals (<week to >year)

CEN 689 Annexes A – G (Informative)

- Origins from different countries
- Developed in early 70's
- Confusing order
- No guideline to choose between different annexes

Still useful !

CEN 689 Annexes A – G (Informative)

A: grab/discrete sample size for one $TWA_{8\ hrs}$

B: $TWA_{8\ hrs}$ calculations from discontinuous measurements $C_T = \Sigma (c_i * t_i) / \Sigma (t_i)$

C & D: Formal evaluation procedures

D,E & F: Periodic measurements

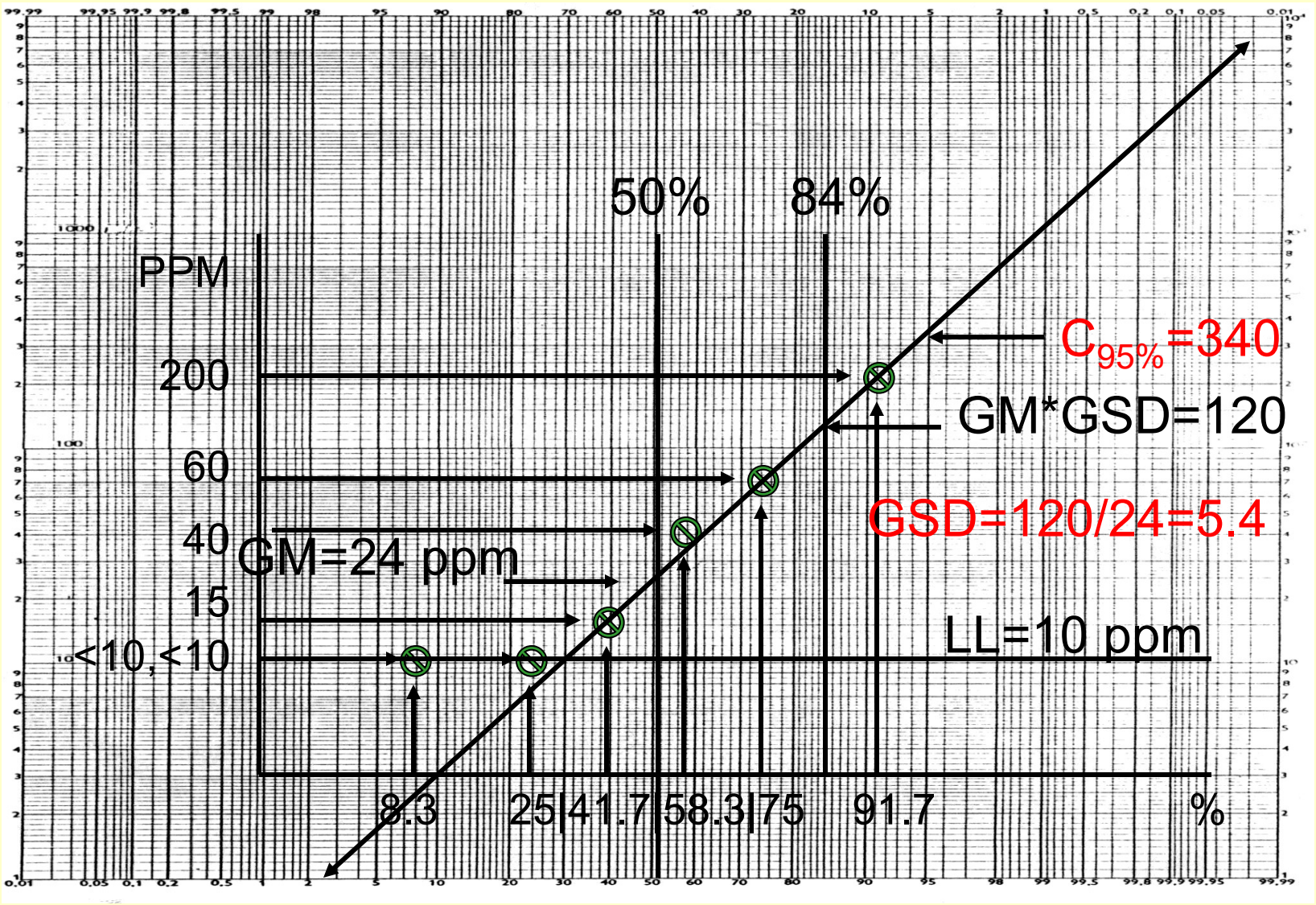
G: Graphical statistical analysis of samples $TWA_{8\ hrs}$ measurements

Lognormal Probability Paper (Annex G)

- Lognormal goodness-of-fit
- Upper tolerance $C_{95\%}$

- Sample of 6 TWA measurements
- 2 measurements < lower detection limit

Rank Statistics (Tables)



Quantitative evaluation of samples with undetectables

- Regression through the detectables and rankit expected values
- Geometric mean GM=50%-tile
- GSD=84%-tile/GM
- Biased $C_{95\%}$! (average underestimate)

Controversies in quantitative assessment

- Short-term (task) and long-term (job,seg)
- Unbiased estimators
- Sample size considerations
- Between worker variability
- Undetectables
- Time trends

Short- and Long-term exposure assessment

Task based

Focus on:

- (Sub) acute effect
- Short term exposure
- Upper tolerance $C_{95\%}$ of the distribution
- Single exceedance prevention $C_{95\%}$< OEL

Job based

Focus on:

- cum. & chronic effects
- Long-term exposure
- Upper confidence of the arithmetic mean $AM_{95\%}$
- Average dose compli-ance $AM_{95\%}$ < OEL

Unbiased statistical methods

- Expectation equals the true value for every sample size
- Exist for:
  - Exceedance $C_{95\%}$< OEL (Wilks 1941)
  - Average dose $AM_{95\%}$ < OEL (Land 1971)
- Cost effective
  - Sample size decreases if $X_{95\%}$ < OEL

Sample Size for Exceedance $C_{95\%}$<OEL (Unbiased, Wilks)

$C_{95\%}=GM*GSD^{k}$

GM/OEL	GSD 2	GSD 3	GSD 5	GSD 10
0.4				
0.3	28			
0.2	6			
0.1	4	7		
0.05	3	4	13	
0.01	3	3	4	9

Sample size for average dose $AM_{95\%}$<OEL (Land)

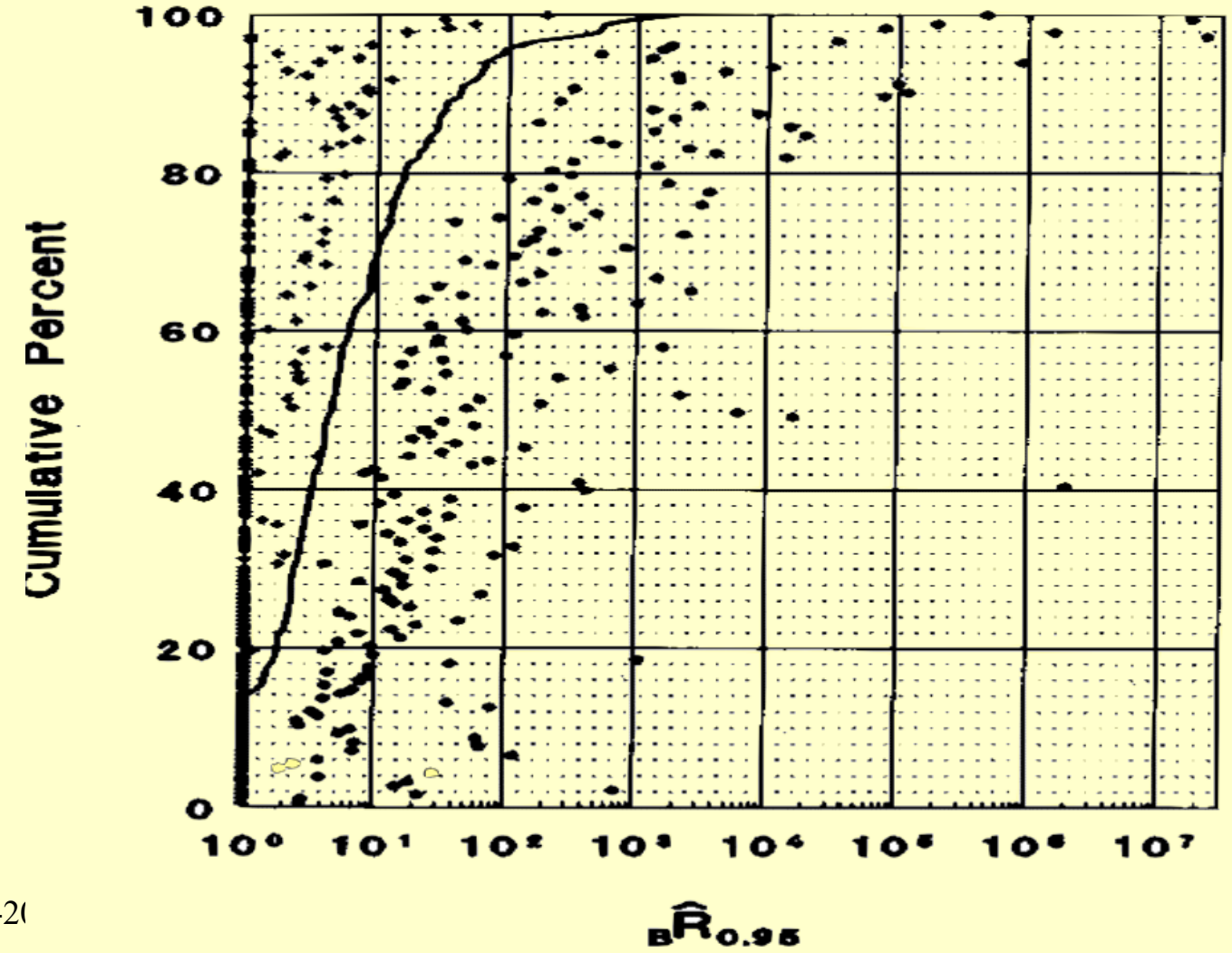
$AM_{95\%}$=f(GM,GSD)

GM/OEL				
0.4	9			
0.3	6/7	25		
0.2	5	13		
0.1	4	8	29	
0.05	3	4	14	>50
0.01	3	3	8	28
GSD	2	3	5	10

Between Worker Variability
CEN 689: $0.5<Am_i/Am_{heg}<2$

< 10% of the exposure series comply

85% of the SEG's show no significant Between Worker Variability!

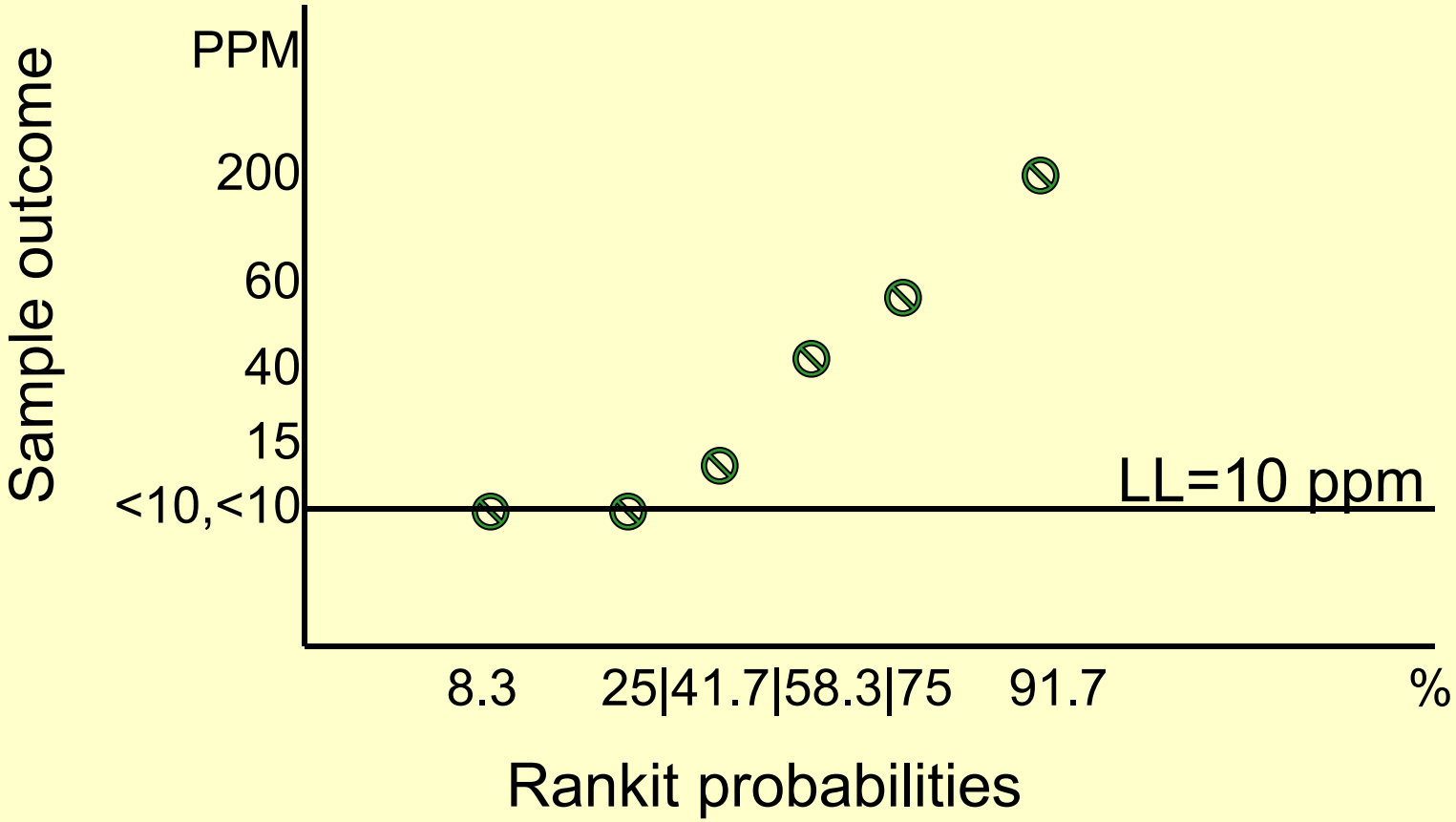


Between Worker Variability

- Use it only if:
  - Workers mean exposures differ significantly
  - Day-by-day variability is small
  - $BW_{\text{biological variability}}$ is small.
  - observation period > 6 months
- Demands extreme high sampling effort
- Stigmatize workers at random as “dirty”

- A toy for the academics

Different ways to estimate descriptive statistics



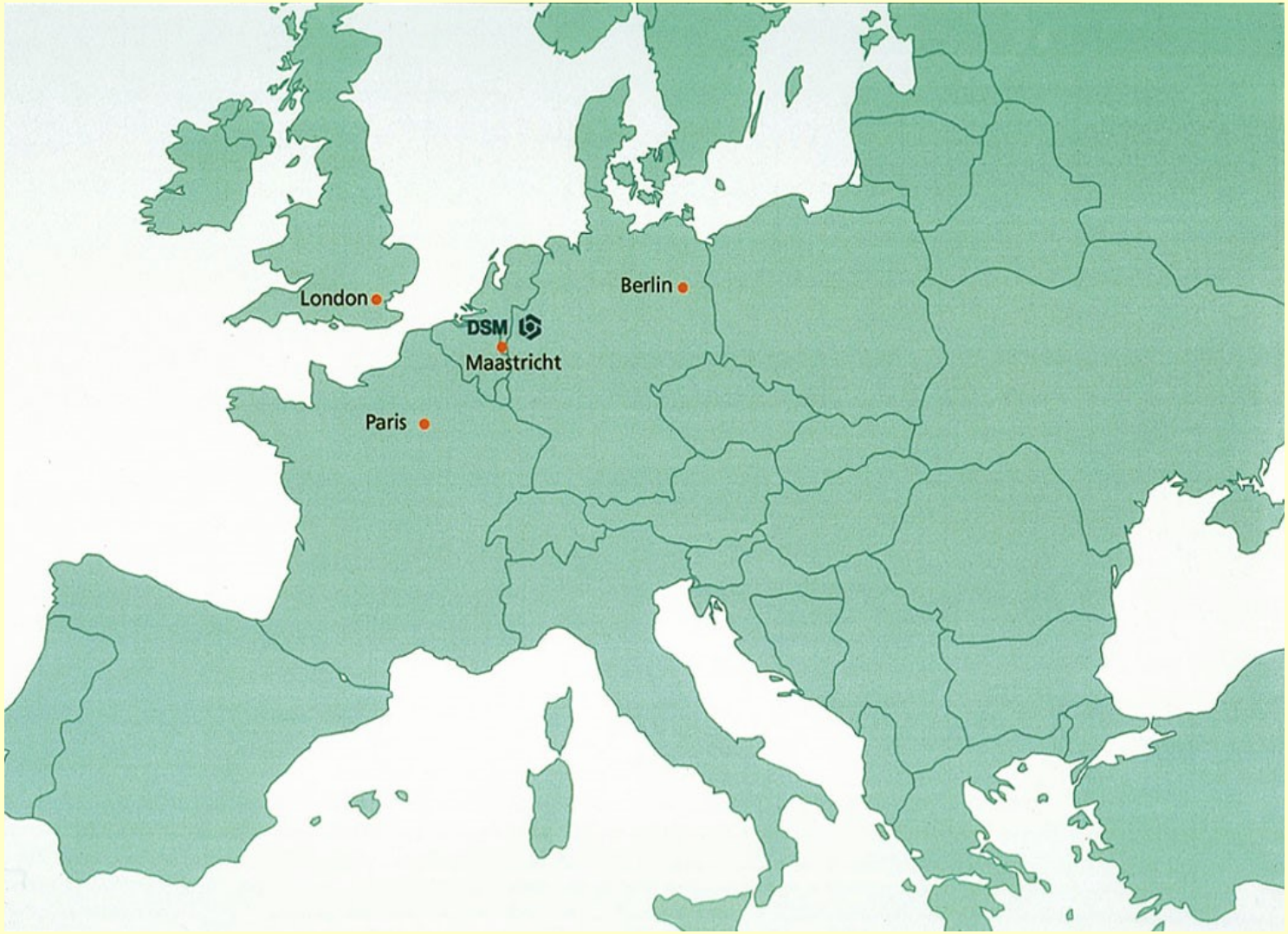
Different methods to treat undetectables

Method	size	GM	GSD	$C_{95\%}$
"True"	6	21.6	5.2	320
Remove	4	51	2.9	302
Ignore	6	30	3.5	233
1/2 LL	6	20	4.3	265
Rankit	4/6	23	5.4	371

Samples with undetectables

- Estimate descriptive statistics using probability paper methods.
- Do not :
  - use half the detection limit
  - remove undetectables
  - ignore undetectables
  - hide samples because the proportion undetectables is to large

EAS at a (bio)chemical production site



DSM site Geleen, the Netherlands

The aim of the long-term exposure sampling policy

- Monitor and control daily exposure
- Estimate workers exposure risk
- Register workers long-term individual working history and exposure
- Responsible care

Exposure assessment strategy

CEN 689/AIHA:

- Similar exposure groups
- High risk oriented
- 10% TLV action level
- Standardized analytical methods
- TWA 8 hour PAS

Deviations:

- non-RPE exposure time only
- stratified sampling plan
- Focus on cumulative agents

Some characteristics

- PAS TWA 8 hours series since 1978
- Chemical & Noise
- Benzene, VCM, ACN, dusts
- SEG based strategy since 1983
- Occupational exposure database since 1987

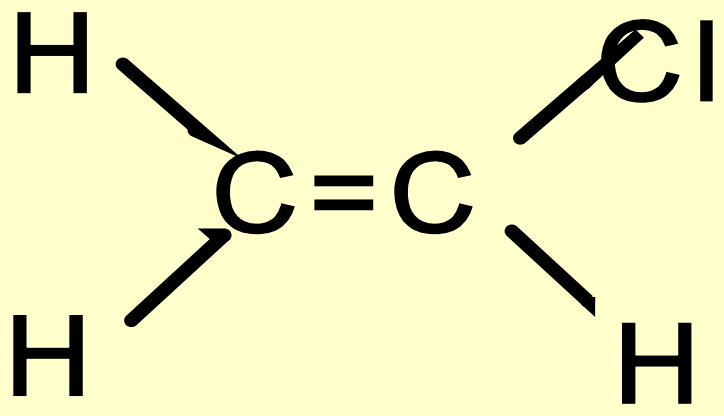
Occupational exposure database

- 10000+ Personal air sampling results
- 4000+ employees
- 400+ similar exposure groups (SEG)
- 100+ SEG based measurement series
- 30+ agents with measurement series

An example: Vinyl Chloride

The European Communities Council Directive of 29 June 1978

On the protection of workers exposed to Vinyl Chloride Monomer
78/610/EEC



78/610/EEC

- VCM limit value (art. 2b & 3.2):
  - three parts per million
  - a reference period of one year
  - a carcinogen

  may not be exceeded by the mean annual concentration.
- Technical $OEL_{8\ hours}$ = 7 PPM
  - Derived from the $OEL_{1\ year}$=3 ppm
  - Acute toxicity is low

Compliance testing

Is the annual (M=200 shifts) arithmetic mean of the worker's daily exposure $C_{\text{eight hours}}$ below the one-year limit value H?

$$C_{\text{one year}} < H_{\text{one year}}$$

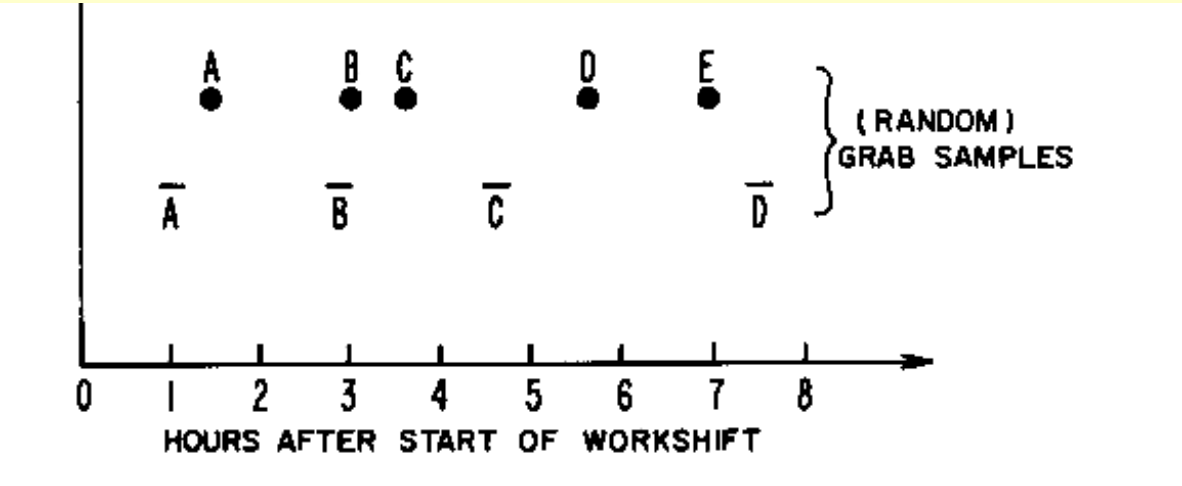
or

$$\frac{\Sigma\, C_{\text{eight hours}}}{M_{\text{eight hours}}} < H_{\text{one year}}$$

No formal EG statistics procedure

Leidel, Busch & Lynch (1977, 3.3.4): Arithmetic mean using consecutive samples whose total duration is smaller than the period for which the standard is defined

Land's method for $AM_{95\%}$



Sampling plan

In a non-experimental setting, stratified sampling is more effective than random (Mietinnen 1985)

Stratified sampling:

- fixed dates in different seasons;
- consecutive shifts (morning/afternoon/night)
- Independent of the activities of that day

Sample size

EG: In the case of discontinuous measurements the sample size should be sufficient to predict with 95% confidence that the mean annual concentration will not exceed the long-term limit value of 3 PPM.

Land's method for $AM_{95\%}$

Sample Size for $AM_{95\%}$<OEL (Land)

GM/OEL				
0.4	9			
0.3	6/7	25		
0.2	5	13		
0.1	4	8	29	
0.05	3	4	14	>50
0.01	3	3	8	28
GSD	2	3	5	10

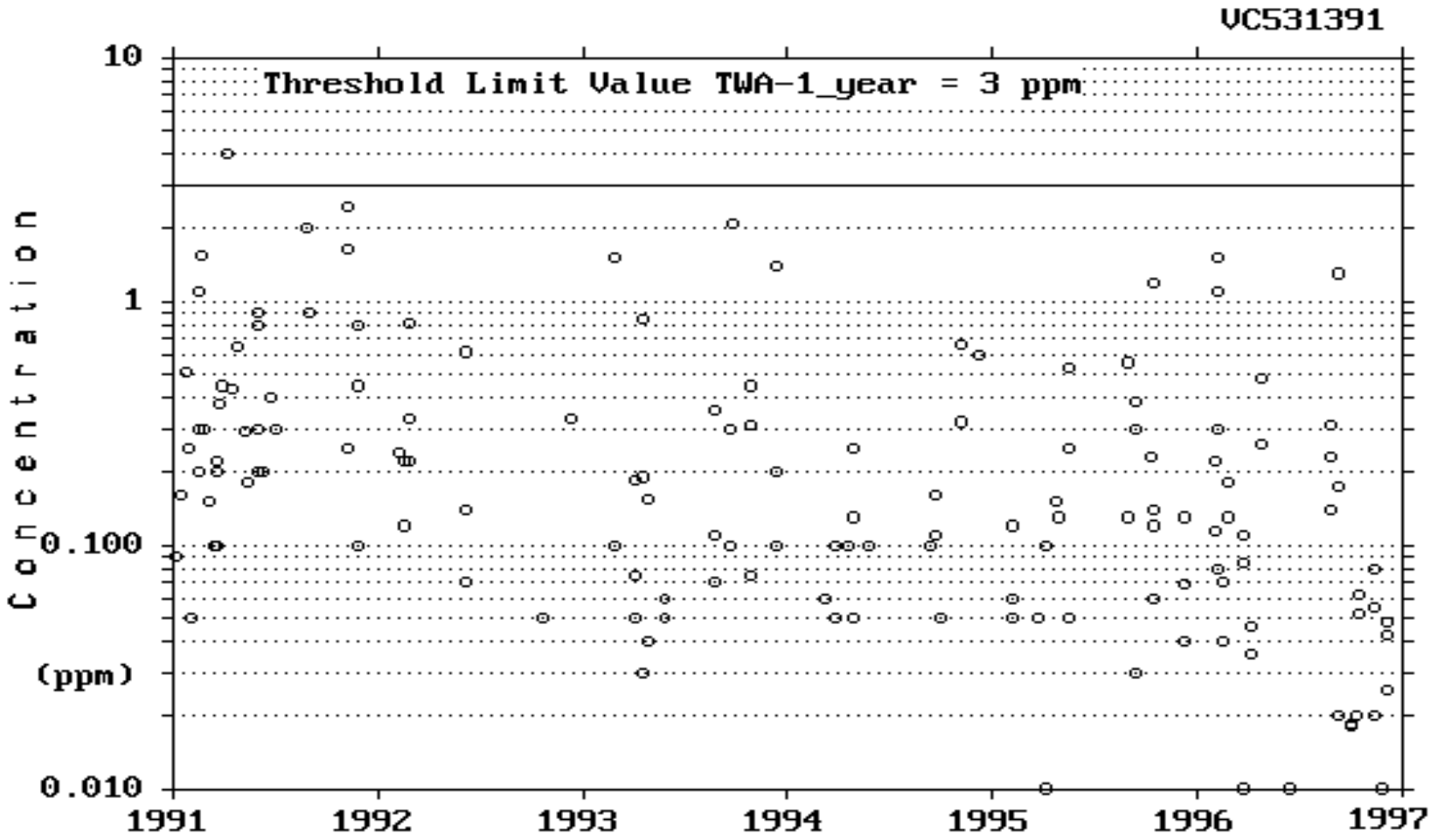
Expand sample size to the strata defined

- Number of shifts
- Number of seasons

Sampling strategy in the PVC plant

SEG	Rating	Number of $TWA_{8\ hours}$
Operators		
- outdoor	**+**	**) 4 times a year on**
- polymerization	**+**	**) 3 consecutive shifts**
Shift supervisors		
- outdoors	**+**	**3 t/y on 3 cons. shifts**
- control room	**-**	**-**
White collar	**-**	**-**

Time chart $TWA_{8\ hours}$ Vinyl Chloride



Exposure trend in time

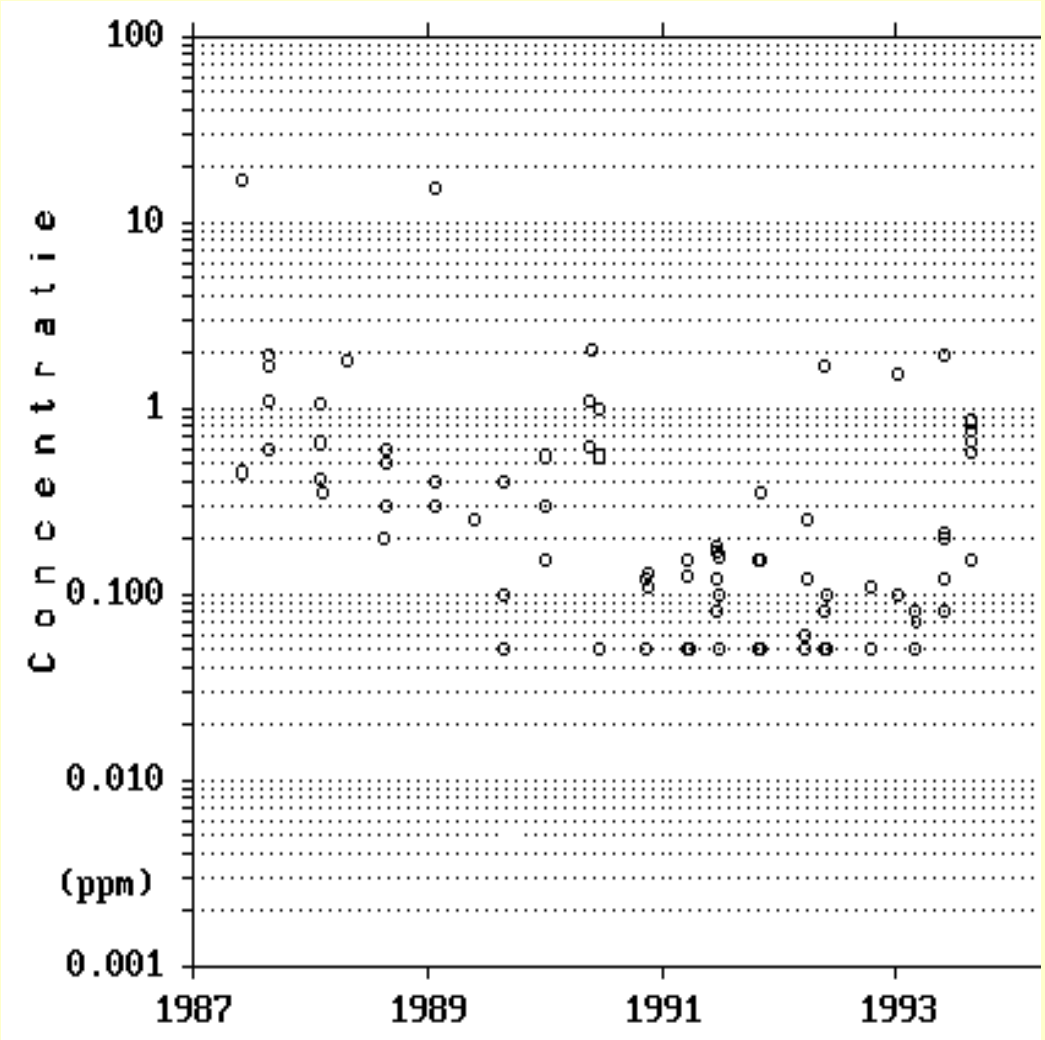
Year	AM	$C_{95\%}$
1991	0.6	2.1
1992	0.3	1.0
1993	0.3	1.4
1994	0.2	0.6
1995	0.2	0.7
1996	0.2	0.8

No linear decrease but a decrease in discrete steps after turnarounds, revamp or redesigns

Trends in time

linear models:

- show a realistic decrease in time
- show a non-realistic, linear trend



Trends in time

linear models:

- show a realistic decrease in time
- show a non-realistic, linear trend
- underestimate GSD
- may lead to auto correlation

Recommendations

Use:

- Graphical methods (trends, descriptives, modeling)
- Exceedance for task & (sub)acute hazard
- Average dose for job & cumulative hazard
- Unbiased estimators for $AM_{95\%}$, $C_{95\%}$ & sample size
- Rankit descriptive statistics for samples with undetectables
- Stratified in stead of random sampling plans

Plan periodic measurements schemes between large intervention moments

Combine models and measurements

Third edition of AIHA's "A strategy…?"