

BW_Statv1.xlsx

The Excel tool for the BOHS-NVvA compliance testing guidance

WORKSHOP B: Gruppierung von Arbeitsplatzmessungen

Deutsche Gesellschaft für Arbeitshygiene e.V.
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Testing Compliance with Occupational Exposure Limits for Airborne Substances



British Occupational Hygiene Society
Pride Park Derby
DE24 8LZ, UK
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September
2011



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The Netherlands
www.arbeidshygiene.nl/



manage exposure in the workplace

Exposure assessment

test compliance
with exposure
limits

This is the bit the NVvA/BOHS guidance deals with

Some past attempts at designing strategies

1966: Coenen, “Zur Frage des Vertrauensbereiches bei Mittelwerten der Staubkonzentration”, Staub

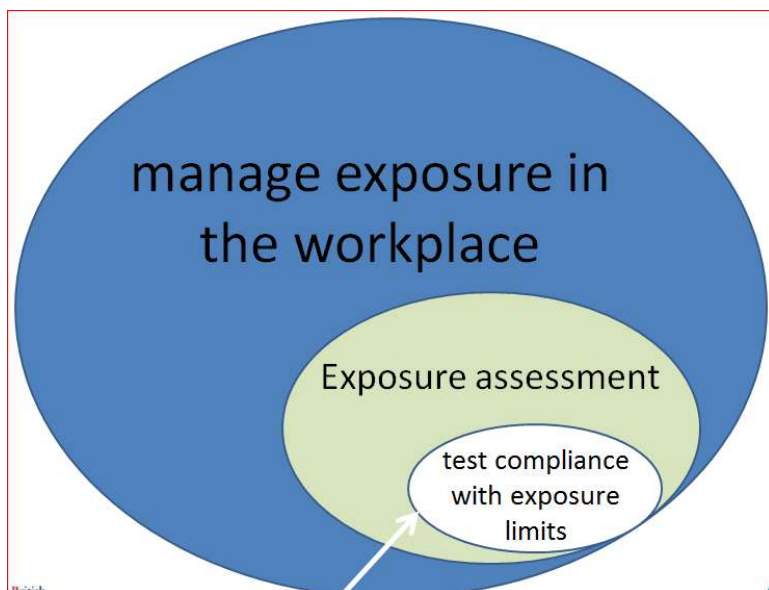
1977: Leidel et al, “Occupational Exposure Sampling Strategy Manual”, NIOSH.

1995: European Standard EN689, “Workplace atmospheres – Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy”

2007: Dutch and British occupational hygiene societies decided to produce new joint statistical guidance, **including individual compliance testing if necessary.**

2014: Update European Standard EN689: synthesis of all developments in the last decades

CEN 689 Occupational exposure assessment (1995)



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

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

This European Standard was approved by CEN on 1995-02-17. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

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

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Ref. No. EN 689:1995 E

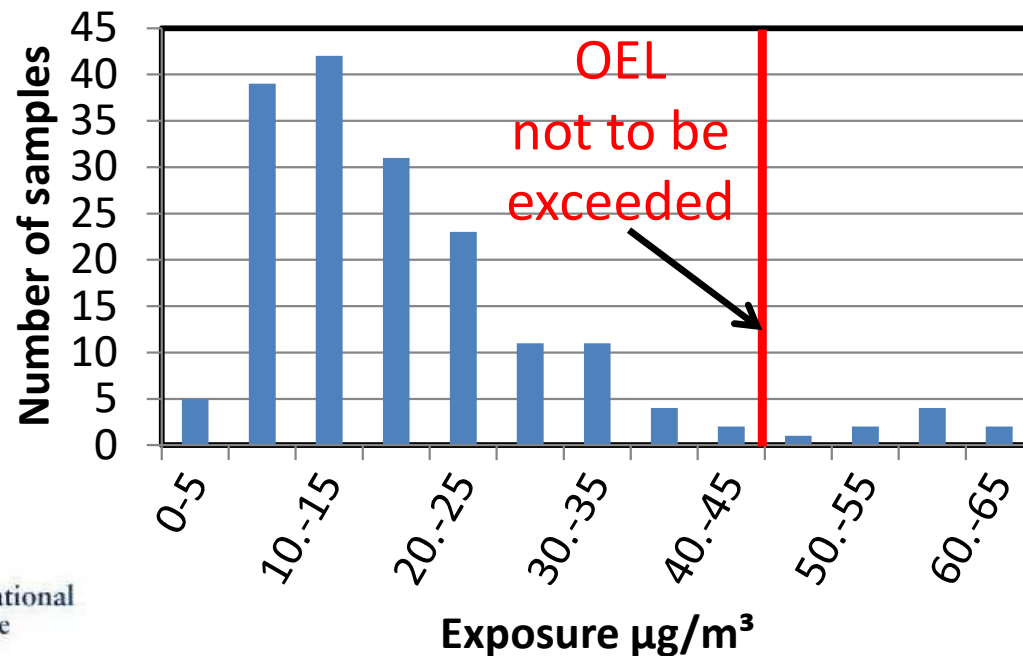
Exposure limits used to be **guidance** for professionals, but regulators treat OELs as sharp dividing lines :

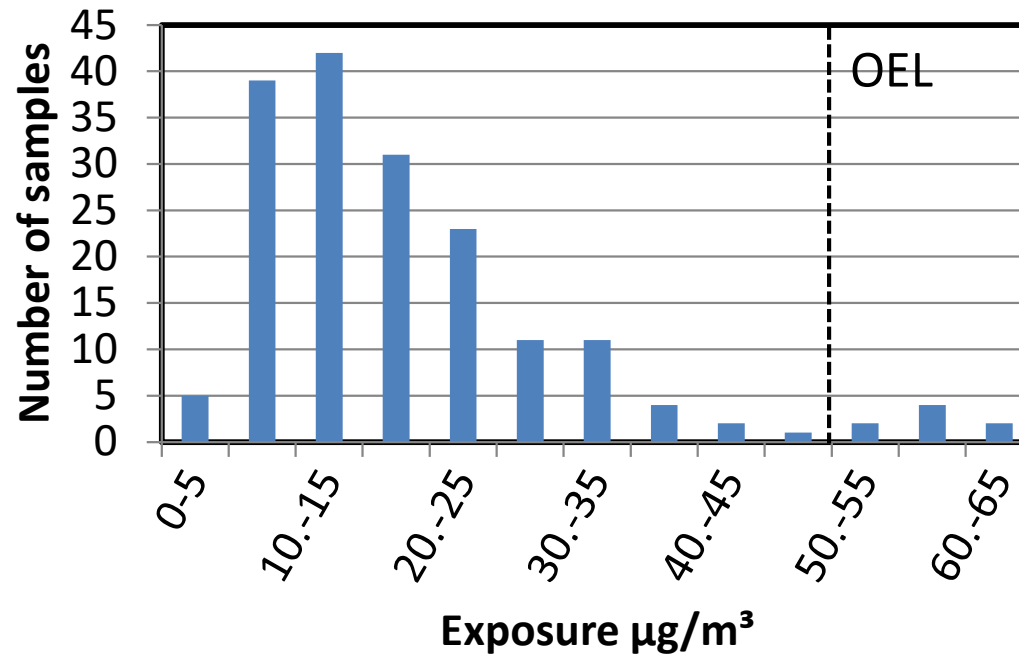
“where an occupational exposure limit value...has been exceeded, the employer shall immediately take steps...”

- *EU 98/24 Chemical Agents Directive Art 6(5)*

“Exposure shall not exceed the limit value...”

- *EU 04/37 Carcinogens Directive Art 5(4)*





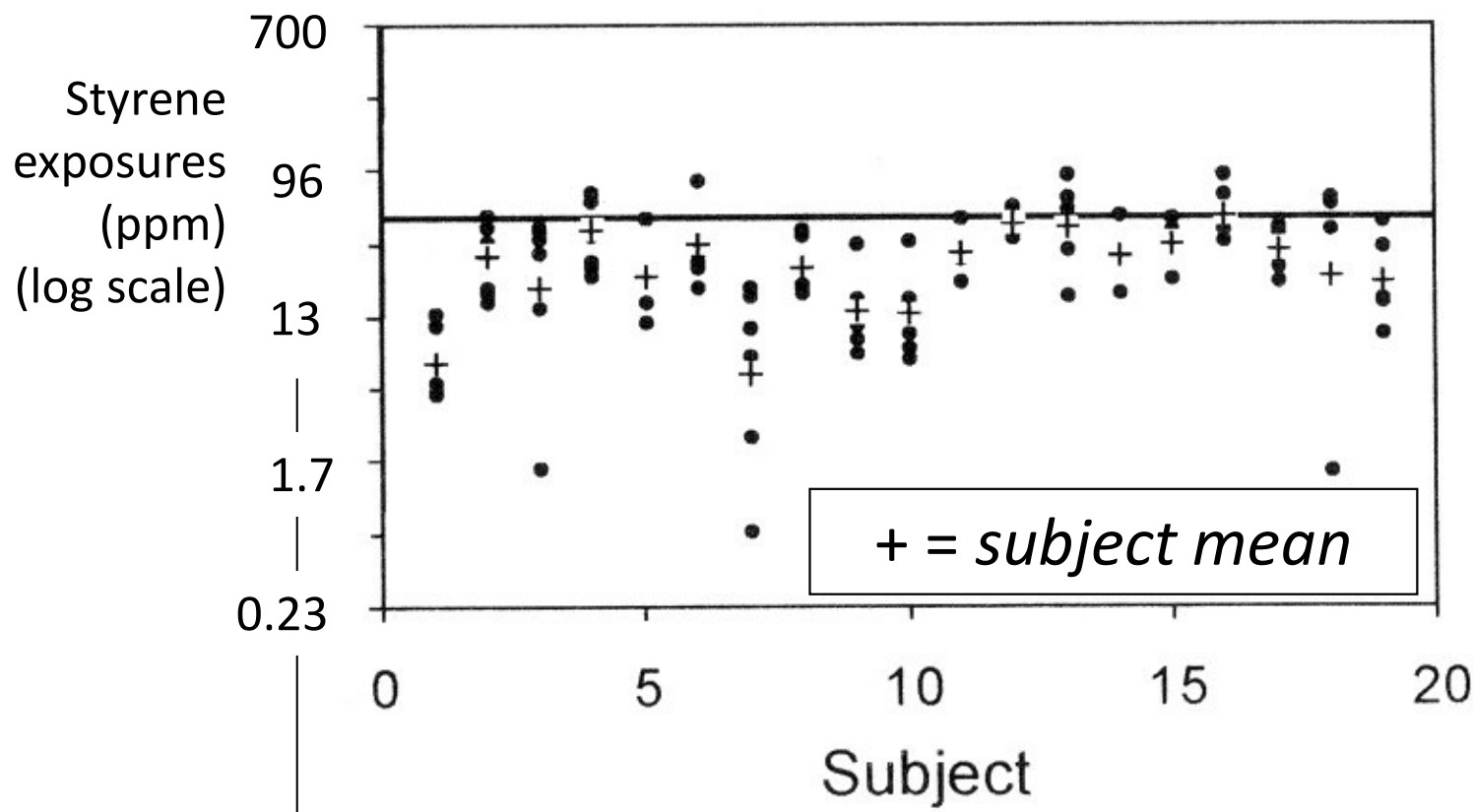
Do I comply?

*An enforcer only needs **one** valid measurement over the OEL to prove you do not comply.*

But no matter how many measurements a hygienist has $< \text{OEL}$, how does he or she know that the next one will not be $> \text{OEL}$?

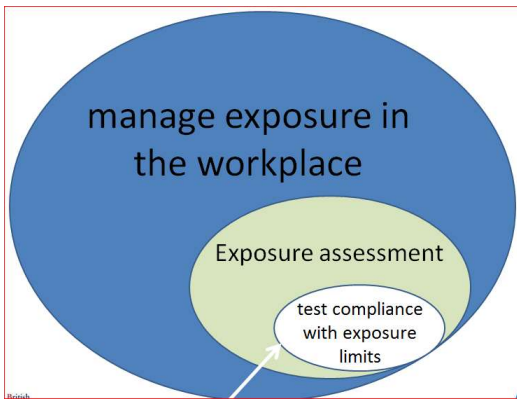
An agreed strategy – how many measurements $< \text{OEL}$, and how far below the OEL, before you can assume that you comply: CEN 689 (2014)

variation in exposure between workers doing the same job ('90^s)



An OEL
applies to
each
individual
worker!

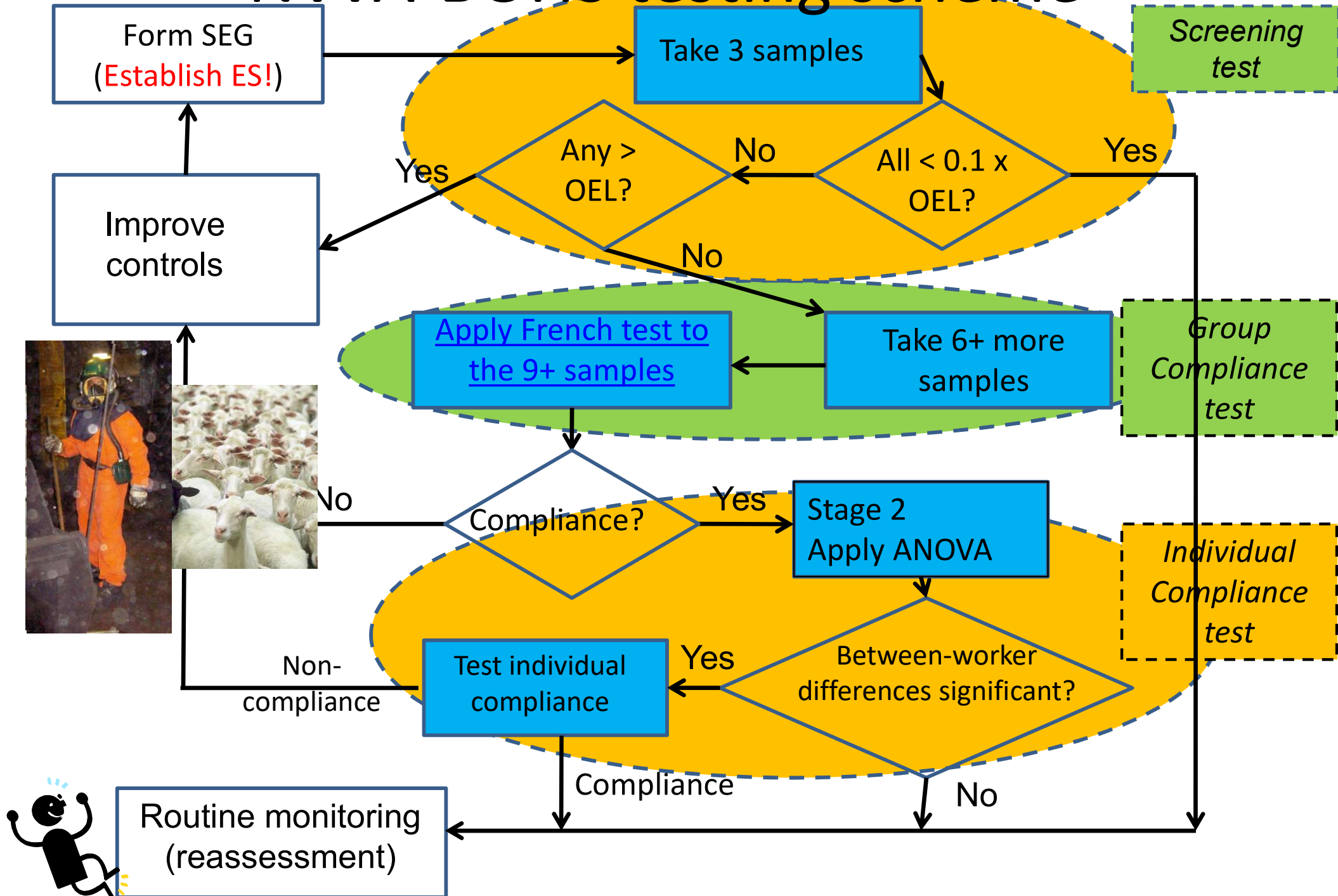
OELs apply to every individual, but exposure on the same job can vary a lot within a Similarly Exposed Group



Structure of the BOHS/NVvA guidance:

- (1) Form Similarly Exposed Groups (SEGs)
- (2) Preliminary test **Three measurements per SEG** to eliminate groups that obviously comply or obviously fail.
- (3) Group compliance **≥ 6 more measurements per SEG** non-compliance if, with 70% confidence, $\geq 5\%$ of the exposures exceed the OEL
- (4) If not, do analysis of variance to see if individual differences are important.
- (5) If so, test **individual compliance**
80% of the workers in the SEG must have $< 5\%$ of their exposures $> \text{OEL}$

NVvA-BOHS testing scheme

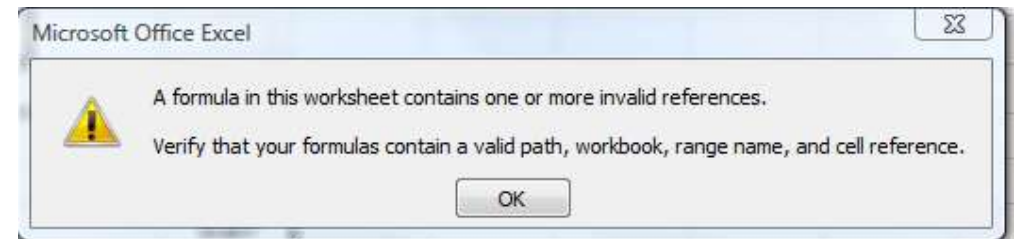


The Excel worksheet BW_Statv1

- Downloadable from
<http://www.tsac.nl/websites.html>
- No more excuses for not using the guidance
 - No extra installation of software, universal excel application
 - Macro-free, no need to enable macro's
 - No extra programming, easy input & output (beware: GIGO!)
- Compatible with Excel 2003,2007, 2010 BUT...

The worksheet

- ... some bugs have been discovered
 - Print_Area's are built in names, if necessary:
give a new name and click OK
 - Some of the formula's read the worker IDs,
when introducing new data, and autocalculate is off,
recalculation might be necessary:
click OK and press F9



Startup screen

BW_Stat_v1.130609.xlsx

Tab Start and Manual

Tab Data

Tab Report

Tab Examples

Bedienungsanleitung

1. Sprache:

2. Stoffname:

3. Messeinheit:

4. Arbeitsplatzgrenzwert:

Geben Sie die analytische Bestimmungsgrenze ein (diese kann auch durch die analytische Bestimmungsgrenze oder durch die analytische Bestimmungsgrenze geschätzt werden):

5. der Log-normalen Wahrscheinlichkeitsgraphik oder durch Multiplikation der analytischen Bestimmungsgrenze mit dem Faktor 3 geschätzt werden):

6. Optional können Sie hier die Nachweisgrenze eingeben:

0,04 mg/m³

7. Geben Sie im Tabellenblatt "Data" die gemessenen Konzentrationen unter Berücksichtigung folgender Punkte ein:

Achten Sie darauf, dass die Einheit der Messwerte dieselbe ist wie die Einheit der Arbeitsplatzgrenzwerte, der

Tragen Sie hier bitte das Datum der Messung (von oben nach unten) ein. Es können max. 50 Daten eingegeben werden.

Geben Sie jeder personengetragenen Messung eine Identifikationsnummer (ID) und tragen Sie diese hier (von links nach rechts) ein. Es können max. 50 Daten eingegeben werden.

Geben Sie die Messergebnisse per personengetragener Messung und Datum ein (hellblaue Felder). Lassen Sie die Felder leer für dessen Kombination Sie keine Messdaten haben.

Geben Sie Messergebnisse < a.B. unverändert als numerische Zahlen ein

Die Hintergrundfarbe verändert sich von grün (<10% OEL) über orange (=50%OEL) bis hin zu rot (>100%) je näher die Messwerte einer Grenzwertüberschreitung kommen.

8. Das Tabellenblatt "Report" zeigt die Grenzwerttestung in 4 Schritten (Phasen) auf, wie Sie auch im BOHS/NVvA Leitfaden beschrieben sind.

9. Benutzen Sie BW_Stat nur nachdem Sie den Haftungsausschluss rechts neben dem Ablaufschema

Figur 5: Ablaufschema der Expositionsbewertung (BOHS/NVvA Leitfaden S. 19)

Start & Manual Data Report Examples

Example n-Hexane

- SEG: workers extracting vegetable oils
- n-Hexane PAS TWA_{8 hrs} measurements
- Legal limit in most EU countries (WEL/IOELV):
 - 72 mg/m³/8 hours
- Sampling methods
 - [Workplace Measurement Method Summaries 2nd IOELV List : HSL/2002/23](#)
 - **PAS active (pump) LoQ=0.1 mg/m³/8 hr**
 - PAS passive (badge) LoQ=1 mg/m³/8 hr

Handleiding

Selecteer uw taal:

Nederlands

Voer de stof naam in:

Voer de meeteenheid in:

Voer de beroepsmatige blootstellingslimiet in (OEL):

Voer de kwantificatie ondergrens in (LoQ=gevoeligheid). Deze is veelal drie keer de LoD maar ook af te lezen in de lognormale waarschijnlijkheidsfiguur):

Voer, indien bekend, de analytische detectie ondergrens in (LoD=nauwkeurigheid):

Voer in het tabblad "data" de gemeten concentratie niveaus in, rekening houdend met onderstaande:

Let erop dat de eenheid waarin je de data uitdrukt dezelfde is als deze van OEL, LoQ en LoD.

Voer de meetdagen aansluitend onder elkaar van boven naar onder in (gele velden), er kunnen maximum 50 meetdagen worden ingebracht.

Voer in regel 2 de werknemers indentificatie in, aansluitend naast elkaar van links naar rechts (gele velden, verplicht), er kunnen van maximaal 50 werknemers meetgegevens worden ingebracht.

Voer de meetresultaten in op alle combinaties van datums en werknemers waarvoor je meetresultaten hebt (lichtblauwe velden); laat de andere cellen gewoon leeg.

Voer de meetresultaten <LoQ zonder aanpassingen in als numerieke getallen.

De achtergrondkleur varieert van groen (<10%OEL) via oranje (=50%OEL) naar rood (>100%OEL) als het meetresultaat oploopt richting OEL.

Het tabblad Report presenteert de beoordeling van de blootstelling in vier stappen (fasen) volgens het onderstaand afloopschema en de tekst van de BOHS/NVvA richtlijn.

Gebruik BW Stat enkel nadat u het voorbehoud rechts van het afloopschema hebt gelezen.

Start & Manual Data Report Examples



Occupational
Hygiene
Society

Working for a healthier workplace

Worked example

1. 3 measurements

- Data entrance (copy/paste)
- Phase 0: Screening test
- Phase 1: Group compliance test

2. Additional 6 measurements

- Phase 1: Group compliance test
- Phase 2: ANOVA/B&W individual differences test
- Phase 3: Individual compliance test

Example n-Hexane

n-hexane		worker1	worker2	worker3
mg/m ³	sample 1	10.00		
IOLV/WEL 72	sample 2		2.50	
LoQ 0.1 & 1	sample 3			0.20

Start & Manual Data Report Examples

Copy red box area from examples : Ctrl-C

Paste : right click mouse -> option Values

Example n-Hexane

Copy paste example data

Report: Screening test

Testing Compliance with Occupational Exposure Limits for Airborne Substances, Sept. 2011
BW_Stat v1.0

Input			
Unit	mg/m ³	Substance name	n-Hexane
Occupational Exposure Limit (OEL)	72.00	total number of workers	3
10% Occupational Exposure Limit (10%OEL)	7.20	total number of measurement days	3
Lower Limit Of Quantification (LoQ)	0.10	total number of measurements	3
Results			
<i>Countings</i>			
Number of samples <10%OEL	2	Number of samples <LoQ	0
Number of samples =>10%OEL and <=100%OEL	1		
Number of samples >100%OEL	0		
Compliance testing			
<i>Stage 0: Screening test (Section 3.3)</i>			
Are any of the samples =>0,1 OEL?	Yes, take additional measurements until sample size equals 9 (section 3.4) or see stage 1 results		
Are any of the samples >1,0 OEL?	No, all samples are below the OEL		
Start & Manual Data Report Examples 			

Report: Group compliance test

Testing Compliance with Occupational Exposure Limits for Airborne Substances, Sept. 2011

BW_Stat v1.0

Input			
Unit	mg/m³	Substance name	n-Hexane
Occupational Exposure Limit (OEL)	72.00	total number of workers	3
10% Occupational Exposure Limit (10%OEL)	7.20	total number of measurement days	3
Lower Limit Of Quantification (LoQ)	0.10	total number of measurements	3
Results			
Countings			
Number of samples <10%OEL	2	Number of samples <LoQ	0
Number of samples =>10%OEL and <=100%OEL	1		
Number of samples >100%OEL	0		
Compliance testing			
Stage 0: Screening test (Section 3.3)			
Are any of the samples =>0,1 OEL?	Yes, take additional measurements until sample size equals 9 (section 3.4) or see stage 1 results		
Are any of the samples >1,0 OEL?	No, all samples are below the OEL		
Stage 1: Group compliance test (Section 3.4)			
UTL95%,70%	449.57	>	OEL 72 mg/m³
Does the group comply with the OEL?	Take additional measurements until samples size equals 9 (section 3.4)		

Examples: n-Hexane

n-hexane			worker1	worker2	worker3
mg/m ³		sample 1	10.00		
IOLV/WEL 72		sample 2		2.50	
LoQ 0.1 & 1		sample 3			0.20
		sample 4	5.00	1.00	
		sample 5		0.20	1.00
		sample 6	25.00		0.10

Start & Manual / Data / Report / Examples

Add black box from Examples : Ctrl-C
Paste option Values : right click mouse

Example n-Hexane

	worker1	worker2	worker3	
sample 1	10.00			
sample 2		2.50		
sample 3			0.20	
sample 4	5.00	1.00		
sample 5		0.20	1.00	
sample 6	25.00		0.10	
Start & Manual Data Report Examples				

Paste option “Values” : right click mouse

Stage 1: Group compliance in control !

Compliance testing

Stage 0: Screening test (Section 3.3)

Stage 1: Group compliance test (Section 3.4)

UTL95%,70%

63.20

<

OEL 72 mg/m³

Does the group comply with the OEL?

Yes, the group is in compliance with the OEL.
Now check if between-worker differences are
important (Section 3.5). See stage 2.

Stage 2: Individual differences important?

Compliance testing

Stage 0: Screening test (Section 3.3)

Stage 1: Group compliance test (Section 3.4)

Stage 2: Apply ANOVA and if necessary Stage 3 (Section 3.5)

P(ANOVA)	0.02	<	p criterium 0,05
P(ANOVA)	Important differences between the workers. Test individual compliance (Section 3.6)		
P(B&W)	72.12%	>	ad-hoc criterium 20%
P(B&W)	Important differences between the workers. Test individual compliance (Section 3.6)		

Stage 3: Individual compliance test

Stage 2: Apply ANOVA and if necessary Stage 3 (Section 3.5)

P(B&W)

Important differences between the workers. Test individual compliance (Section 3.6)

Stage 3: Individual compliance test (Section 3.6)

Probability that any worker has an exposure 95%-tile >OEL

11.12%

<

ad hoc criterium 20%

Is there $\geq 20\%$ probability that individual workers' exposure 95%-tile >OEL?

No. Go to routine monitoring (reassessment) (Section 3.8)

Statistics

Start & Manual

Data

Report

Examples



Undetectables (n-Hexane example)

Workplace Measurement Method Summaries

2nd IOELV List : HSL/2002/23

- PAS active (pump) detection limit 0.1 mg/m³/8 hr
- **PAS passive (badge) detection limit 1 mg/m³/8 hr**
 - Valid method LoQ < 10% of OEL 72 mg/m³/8 hr

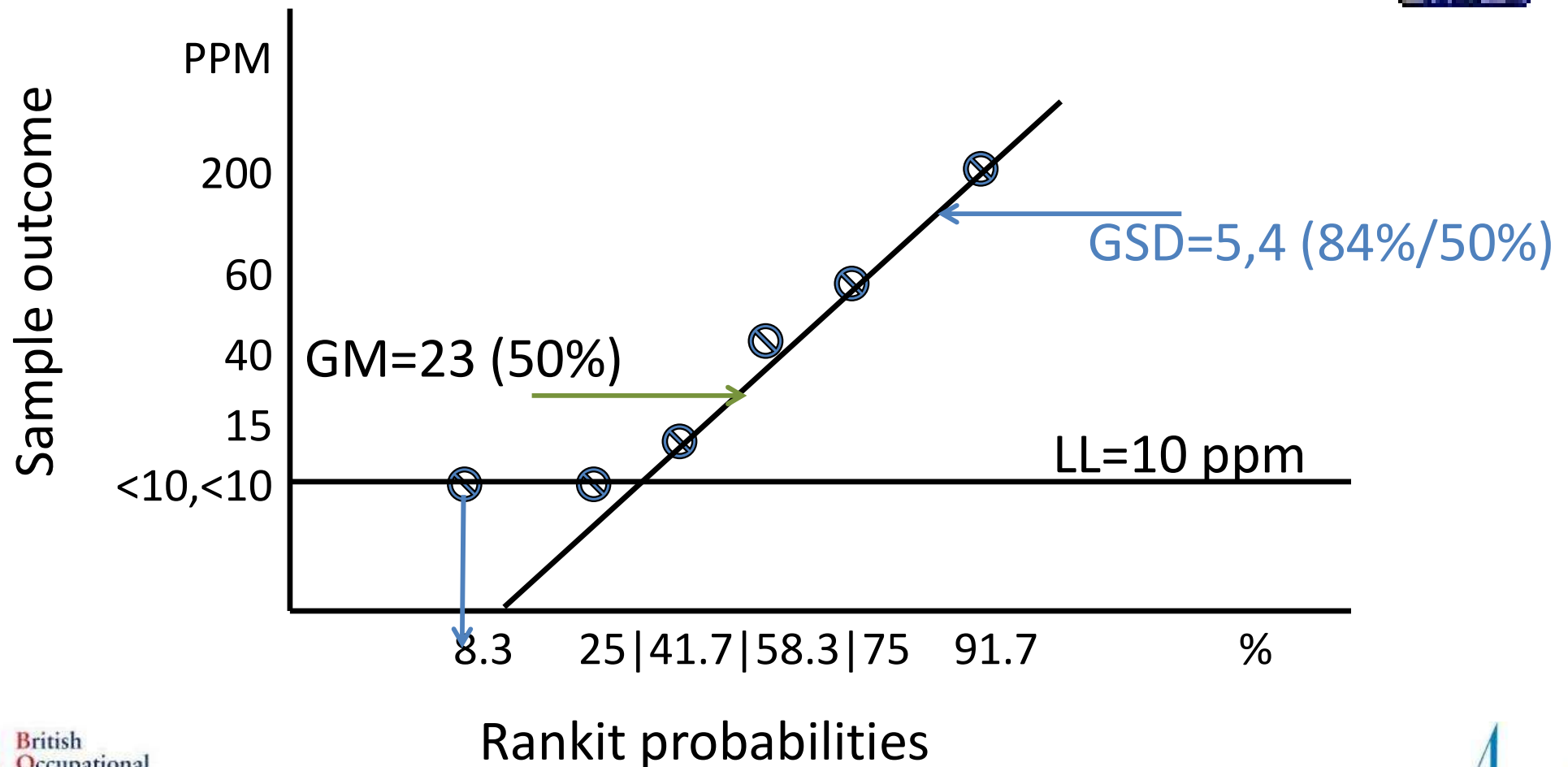
How to handle undetectables

- Schneider H. Truncated and censored samples from Normal populations. Statistics: textbooks and monographs. Vol 70 (1986).
- Fisher R.A. The truncated Normal Distribution. British Assoc. Adv. Sci. Math. Tables I, 1931 pp XXXIII



How to handle undetectables

Lognormal probability plot of exposure distribution with undetectables



**Estimating GM and GSD from sampling
data with undetectables**

**Regression through the data above LoD
and optimizing GM and GSD using
Shapiro & Wilks Goodness-of-Fit**

HYGINIST 4.2.3

Future developments

- Incorporation in CEN689 Update Annex
- Harmonization & Standardisation of compliance testing: IOHA2015 London
- Combining effort with Canada towards BW_Stat_v2 (non detects, Levine, web based)

Contact information

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