GDS & exposure variability

CEN689

Operational Conditions (OC) & exposure variability

Low GSD	High GSD
Clean room, well controlled industrial OC	Outdoor, Professional OC
Job with single task	Job with multiple tasks
High background level	No background inference

Strategy & exposure variability

Low GSD	High GSD
Short sampling campaign (1 day, one week): autocorrelation, missing tasks	Long-term, mutually independent sampling campaign (months, year)
EM	PAS
Small sample size	Large sample size
Small detection range (Gravimetric, inorganic acids)	Broad detection range (Analytical: AAS, DPP, IC , EC, etc.)
Fixed factor or remove undetectables	Correct handling undetectables

GSD for uncensored sample

$$GSD = \mathrm{EXP}(s)$$

$$s = \sqrt{\frac{\sum_{I=1}^{M} \left(x_I - \bar{x}\right)^2}{M-1}}$$

M sample size, Xi log(concentration)

GSD reported in literature

GSD	range $UTL_{95\%}$: $GSD^{\pm 1,64}$	Orders of magnitude	Comment, reference
2	0,3-3,0	1	Leidel 1977
2,7	0,2-5,0	1^{+}	Median, Buringh 1991
≤3	0,15-6	2-	Valid SEG, AIHA IHStat
5,1	0,06-15	3^{+}	Median, Scheffers 2000
17	0,01-100	5	95%, Scheffers 2000

long-term GSD in chemical industry

Tijdschrift voor toegepaste Arbowetenschap 13 (2000) nr 4

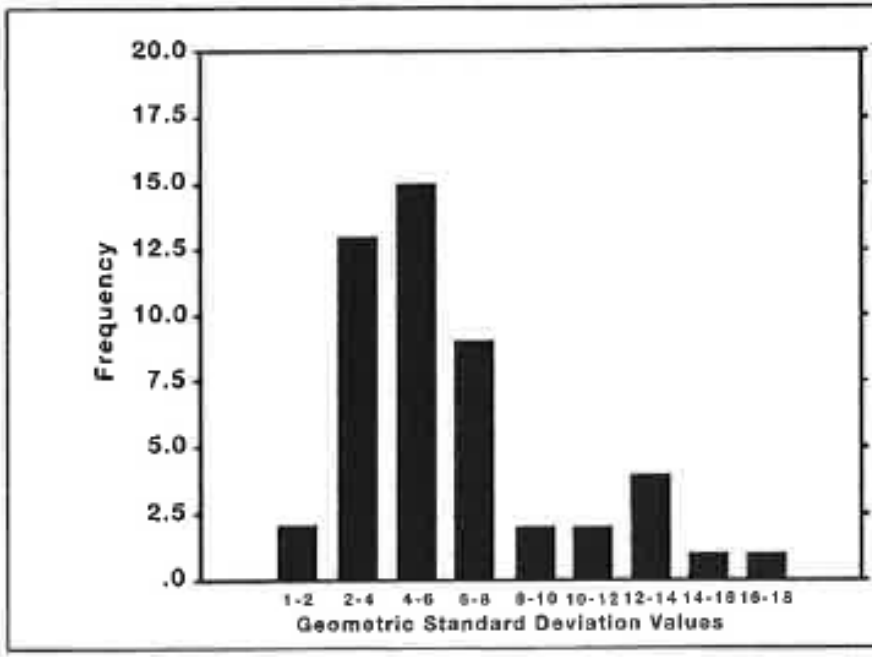
T.M.L. Scheffers[1], J. Marquart[2], J.J. Twisk[3]

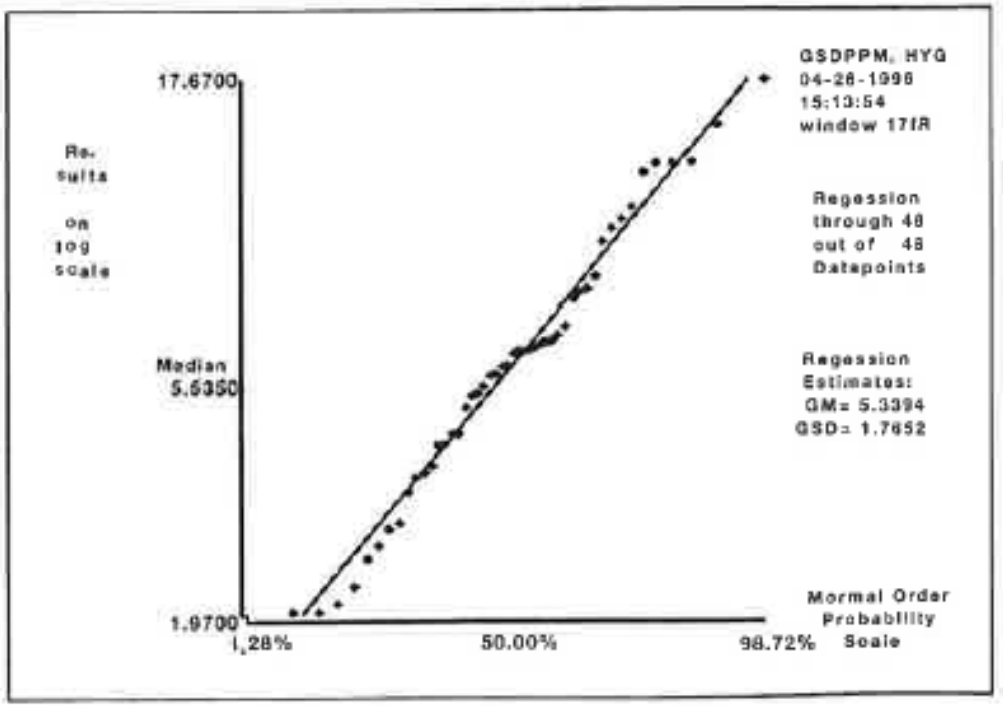
Summary

Long term GSDs are reported of the daily exposure pattern in similar exposure groups in chemical industry. The GSDs vary between 2 and 17, with a median of 5.3. The exposure variability in daily exposure seems to be much higher than was assumed until recently. The fraction of the GSD explained by trends in time or between worker exposure variability seems to be irrelevant in these series. Possible causes of small GSDs in the past are a changed exposure pattern (decreasing background exposures and an increase of multy-craft jobs) and the worst-case exposure assessment starategies used in former days.

1. DSM Limburg BV, Arbeidshygiëne en Epidemiologie, Postbus 601, 6160 AP Geleen, theo.scheffers@dsm-group.com
2. TNO Voeding, Blootstellingsonderzoek, Postbus 360, 3700 AJ Zeist, marquart@voeding.tno.nl
3. Dow Benelux, Terneuzen.

GSD frequency and cumulative distribution

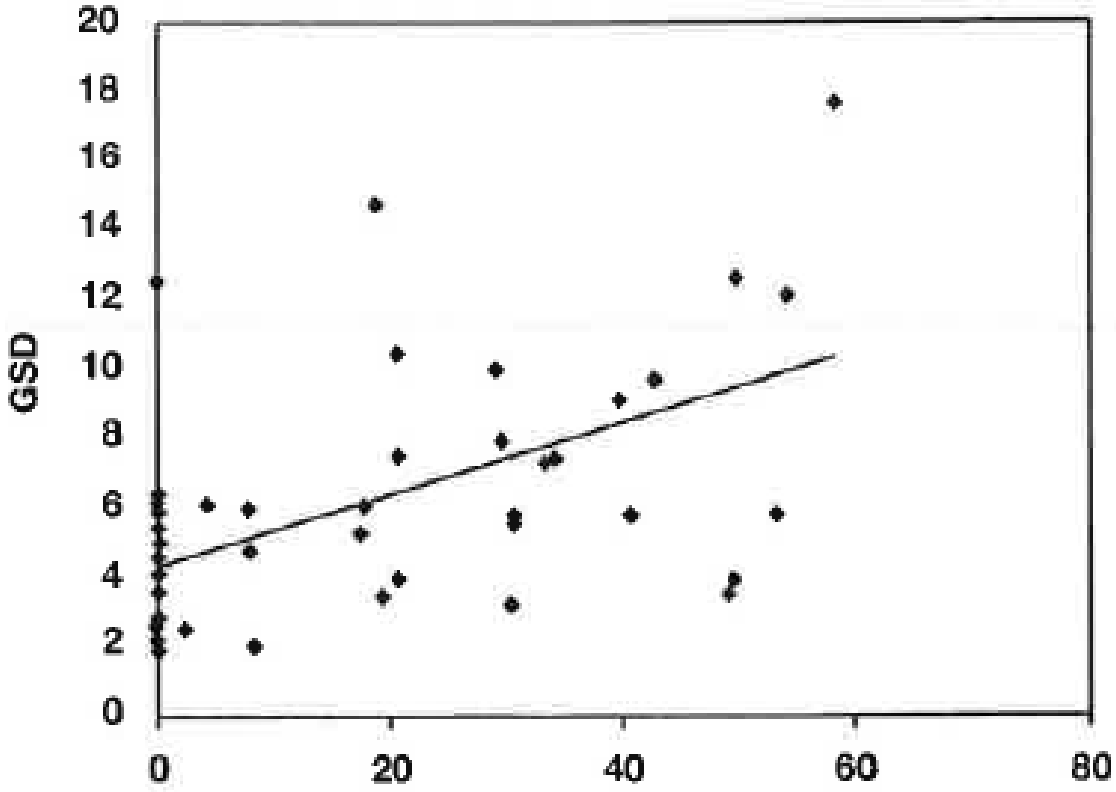




GSD and the 95%-tile

- GSD=1,5 $0,5 \leq C_{95\%} \leq 2$ (inorg. acid mist)
- GSD=2 $0,3 \leq C_{95\%} \leq 3$ (gravimetric)
- GSD=3 $0,16 \leq C_{95\%} \leq 6$ (analytical:
- GSD=4,1 $0,1 \leq C_{95\%} \leq 10$ halogens,
- GSD=5,4 $0,07 \leq C_{95\%} \leq 14$ metals,
- GSD=11 $0,02 \leq C_{95\%} \leq 50$ P, N, S and
- GSD=17 $0,01 \leq C_{95\%} \leq 100$ solvents)

GSD increase with



GSD for censored sample

Regression GSD^g, to adjust for non-detects

$$GSD^g = EXP\left(\frac{\sum_{i=ll}^{i=ul} R_i * x_i - \frac{\sum_{i=ll}^{i=ul} R_i \sum_{i=ll}^{i=ul} x_i}{M'}}{\sum_{i=ll}^{i=ul} R_i^2 - \frac{\left(\sum_{i=ll}^{i=ul} R_i\right)^2}{M'}}\right)$$

R: normal order statistic. M' sample size detectables
j=ll the first outcome above the lower detection limit
j=ul the last outcome below the upper detection limit

Why GSD is underestimated at large in OELV compliance control

- Small sample size: series of 2 to 6 measurements underestimate the GSD on the average
- Short sampling program during one or some consecutive days
  - autocorrelation and underestimation of the temporal variability
- Sampling during a selected part of the OEL reference period
- Focus on one task (ignoring other tasks in the SEG)
  - in a REACH exposure scenario
  - assessing a single combination of Operational Conditions (OC) and Risk Management Measures (RMM) in industrial or professional use
- 2-decades analytical detection method (like gravimetric dust and inorganic acid sampling)
- Sloppy handling of non-detects (LoD/2)
- Use of old-time data (databases) when workers had 1 task per shift
- High background levels

Flaws causing GSD≤3

High background level:

workplace with a relatively high constant background, camouflaging spatial and temporal variability caused by workers activity

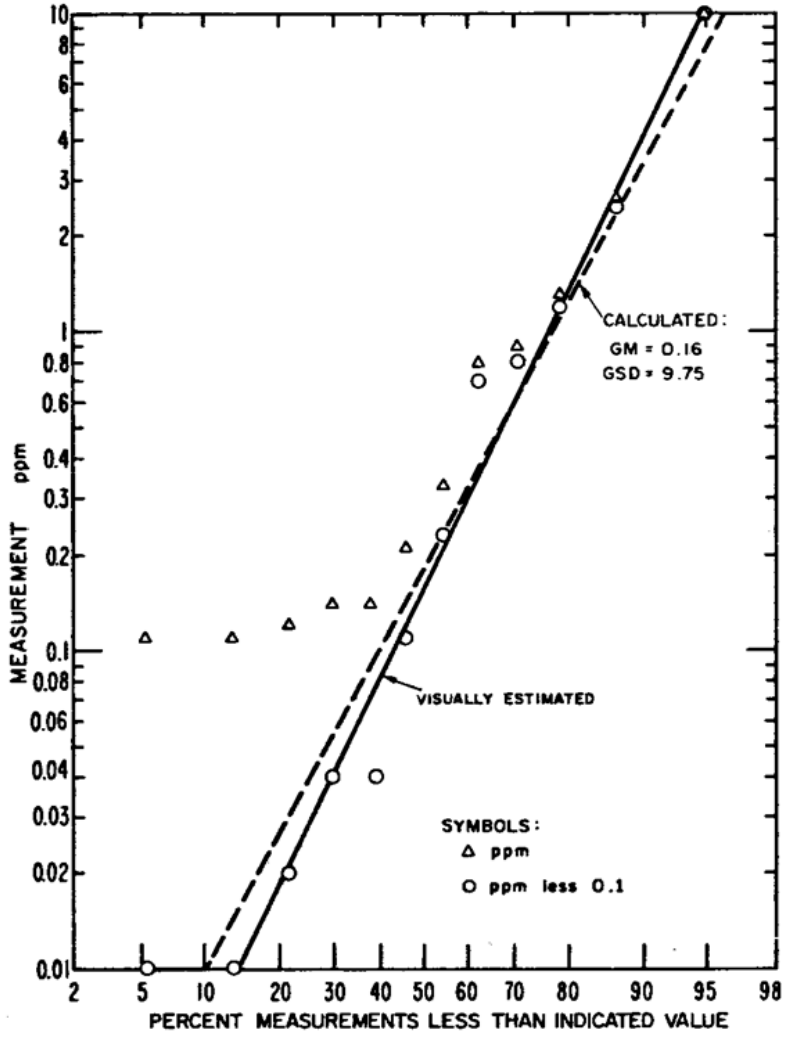


Figure I-4. Hydrogen fluoride measurement distribution.

True SEG GSD≤3

- single-task operations at a fixed workplace (as in the early days of process industry and assembly lines)
- in highly controlled indoor workplaces like clean rooms etc.
- workplaces with a relatively high constant background, camouflaging spatial and temporal variability caused by workers activity

Recommendation

- Do not refer to (flawed) studies in the past on exposure variability and
- remove the phrase “Studies on the variability of exposures [1.2.3] show that for professional activities relatively under control, GSD values are generally less than 3.”

Conclusion

- Small and large GSDs are both possible
- Compare GSD with what is usual for the specific situation:
  - in history
  - In large databases (Colchis, Mega)
  - Read across
  - Modelling
  - Physical-Chemical properties
  - Controls