



Advancing Worker Health Protection

9th - 13th June | Aviva Stadium | Dublin

4. PAS Airsampling workplaces

From sampling duration to limit value duration

Measurement uncertainty

(AIHA 4th edition, EN689 clause 5.1).

NVvA 2024 – PBC Woudschoten 9-4-2024

IOHA 2024 – PDC-150 Dublin 9-6-2024

Peter van Balen

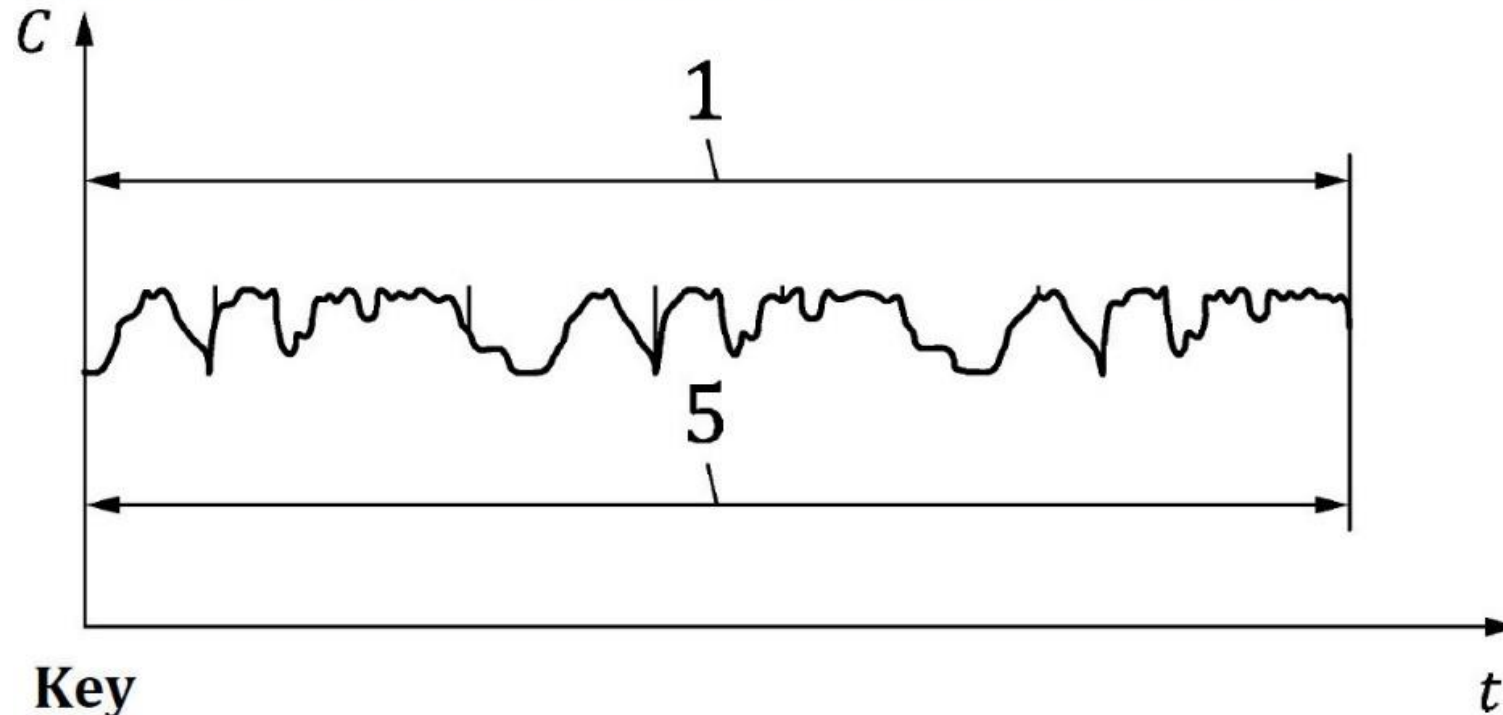
Robbert Emonds

Theo Scheffers



EN-689 2018:2019 – ANNEX D

Annex D : Exposure pattern, OELV reference period and sampling duration
Total Sampling Duration (TSD_{max}) applies for the full work shift (WS)
 $TSD_{max} = WS = OELV_{ref}$. And therefore $C_1 = C_5$ should not exceed OELV



Key

C exposure concentration
 t time

1 $TSD_{max} = WS$
5 WS

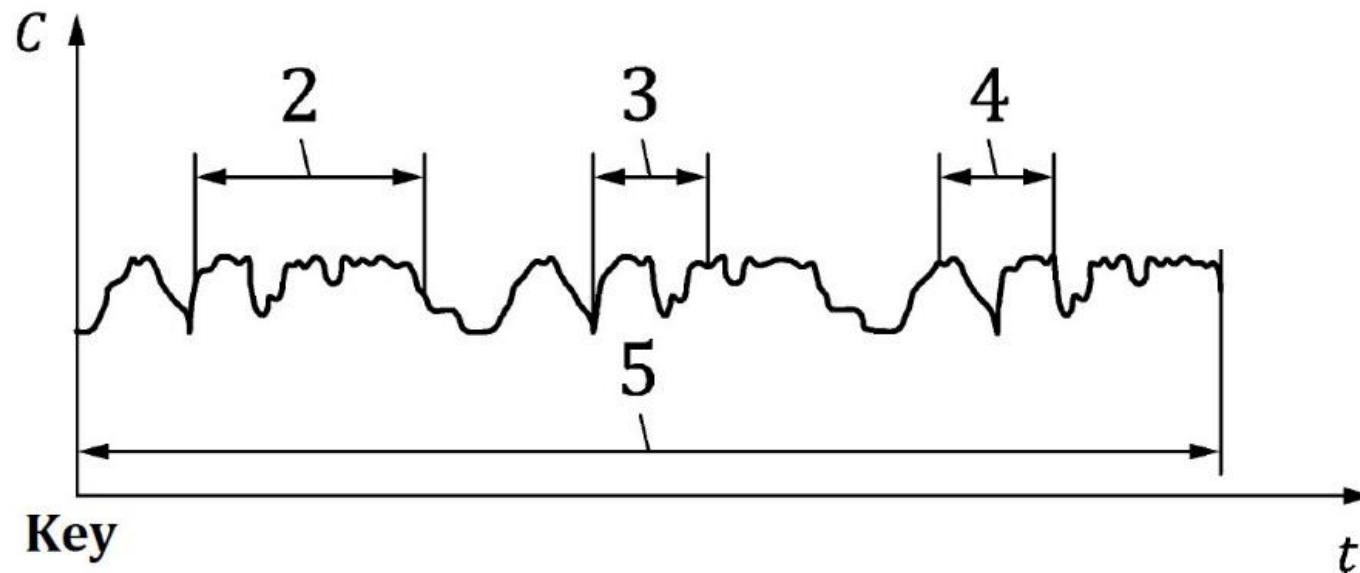
Workplace factors are constant during work shift

Annex D. a) Workplace factors are constant during the full work shift (WS)

Measure during one or more periods of exposure

Total sampling duration (TSD_{min}) should be a minimum of 2 hours

Exposure of the sampling period $C(TSD_{min})$ = the full work shift exposure C_{ws}



C	exposure concentration	2	$TSD_{min} = 2 \text{ h}$
t	time	3 and 4	$TSD_{min} = 1 \text{ h} + 1 \text{ h}$
		5	WS

Figure D.1

Workplace factors are not constant during work shift

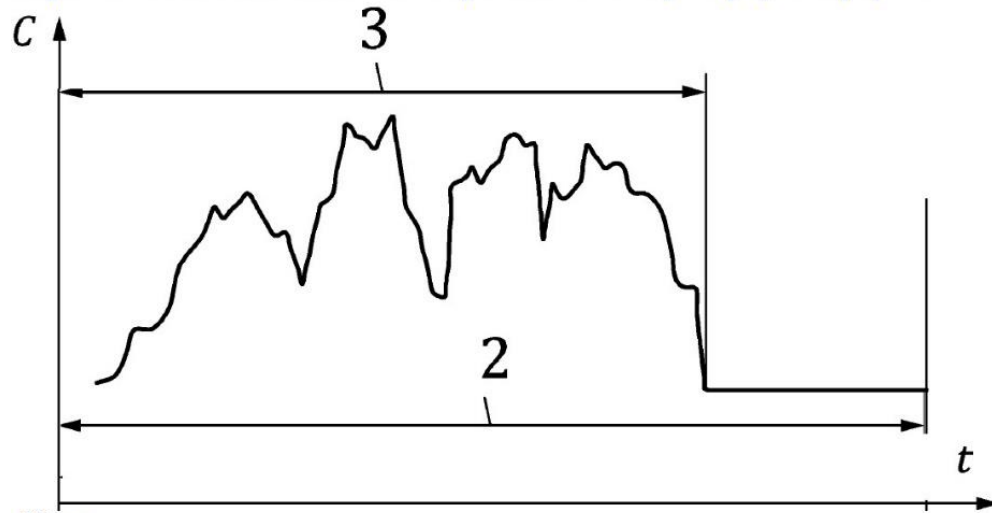
Annex D. b) Workplace factors are not constant during the full work shift (WS)

1) Exposure occurs during a part of shift

Establish that the exposure for the rest of the shift is zero

Only the period (3) of exposure (TSD_{pe}) is measured

Exposure of the full work shift exposure: $C_{ws} = C(TSD_{pe}) * TSD_{pe} / WS$



Key

C exposure concentration

t time

Figure D.2

2 WS

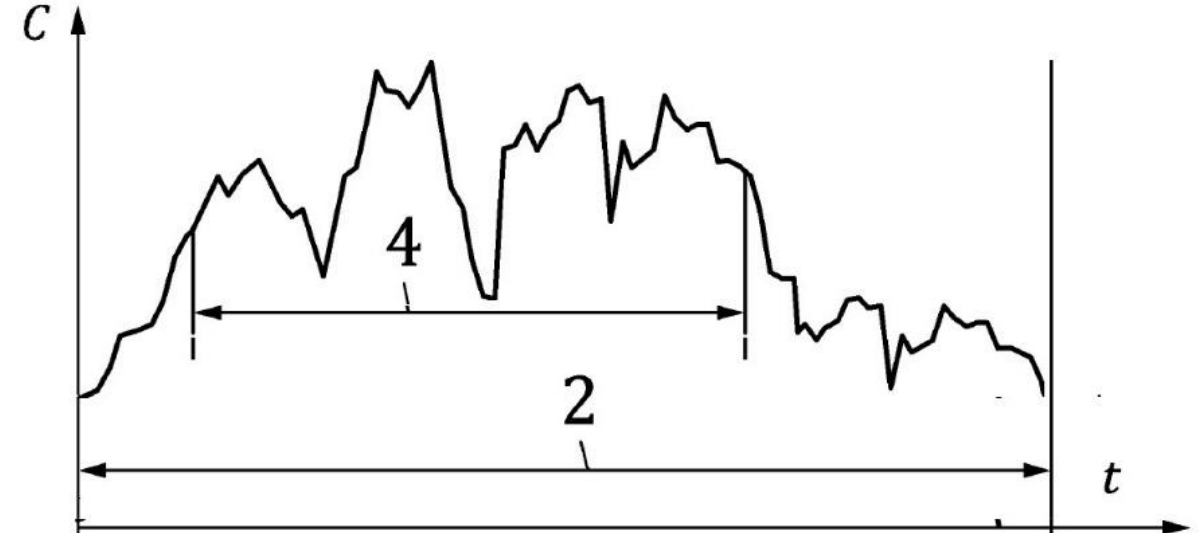
3 TSD_{pe}

Annex D. b) Workplace factors are not constant during the full work shift (WS)

1) Exposure is high during a part of shift

Only the period (4) of highest exposure (TSD_{he}) is measured

Assume that $C(TSD_{he})$ applies for the full work shift exposure C_{ws}



Key

C exposure concentration

t time

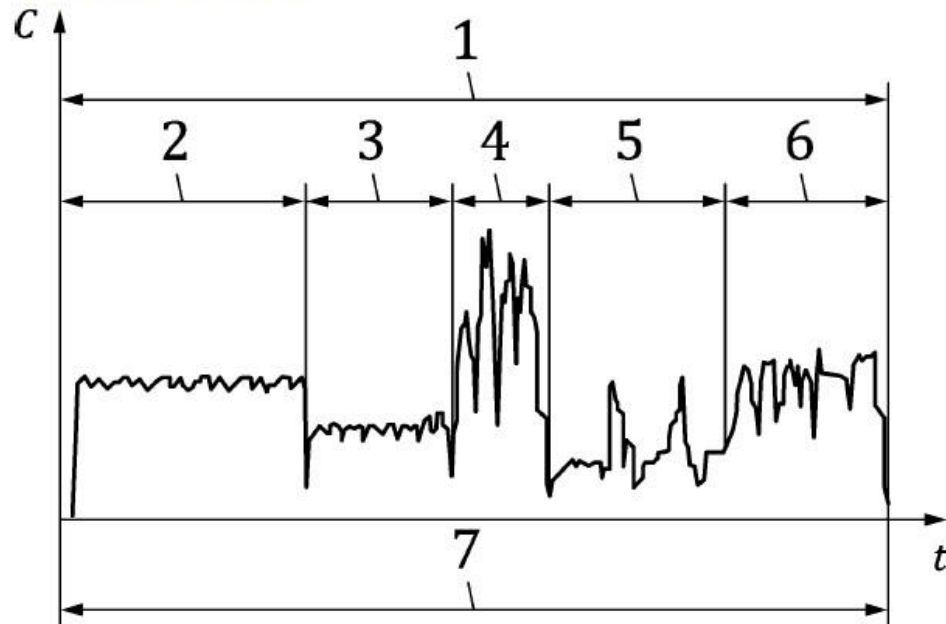
Figure D.3

2 WS

4 TSD_{he}

Workplace factors are not constant during work shift

Multiple exposure profiles during the whole shift.



Key

C exposure concentration

t time

1 TSD = WS

2 TSD _{$i=2-6$}

7 WS

Figure D.4

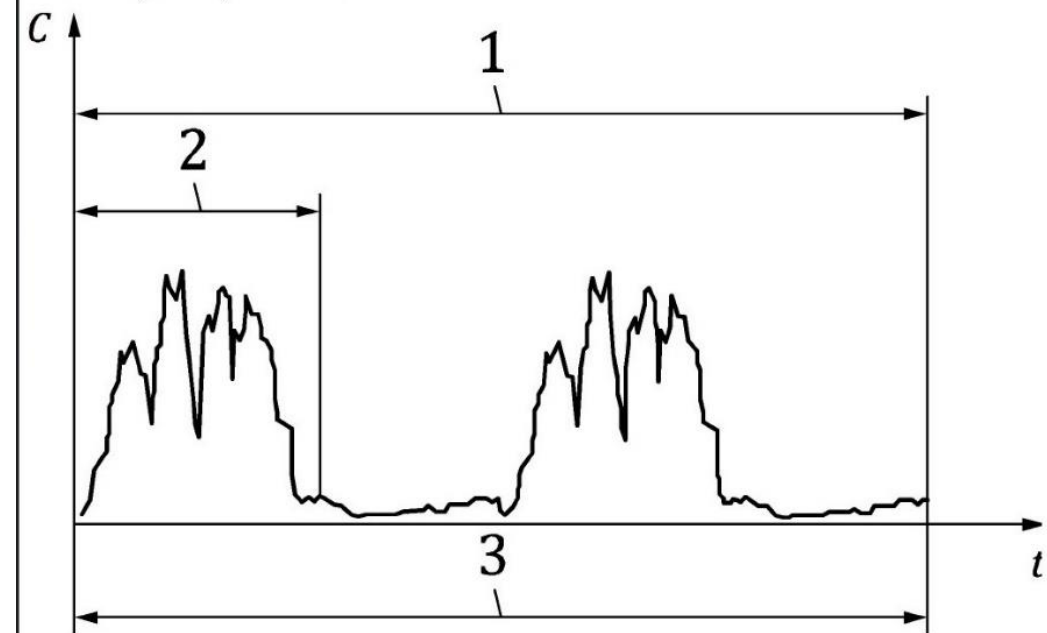
Annex D.2 b) Workplace factors are not constant during the work shift (WS)

3) Single exposure profile repeated n times during the whole shift

Measure for the period of highest exposure (TSDHE) if based on the basic characterization, this period of the highest exposure can be reliably determined. This exposure is assumed to apply for the period of exposure.

NOTE In this situation special attention is paid to peaks of exposure (referred to 5.1.1).

$C_{ws} = C(\text{TSDhe})$



Key

C exposure concentration

t time

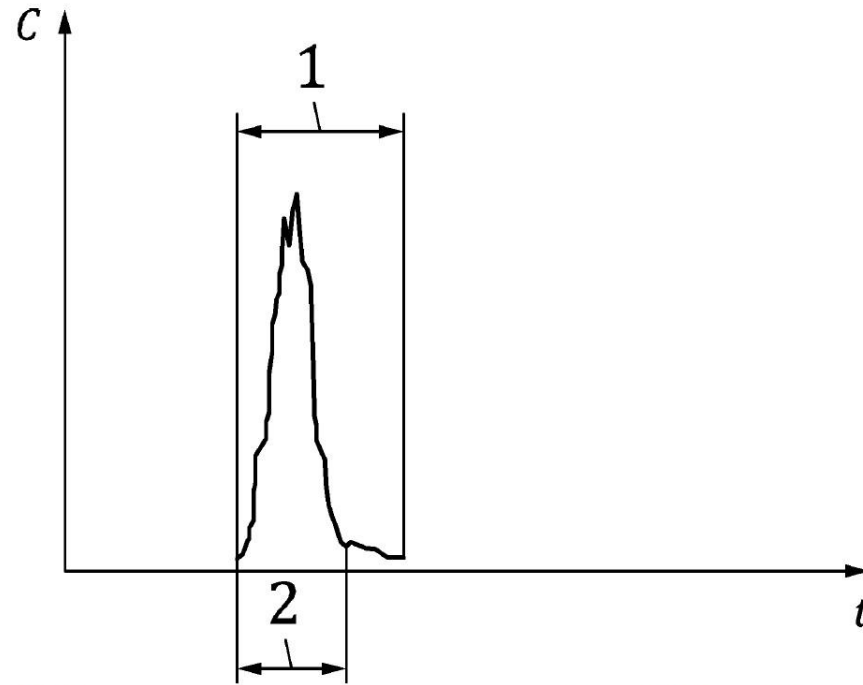
1 TSD = WS

2 TSD_{HE} = 2 h

3 WS

Figure D.6

Workplace factor (task) differs from Reference Period



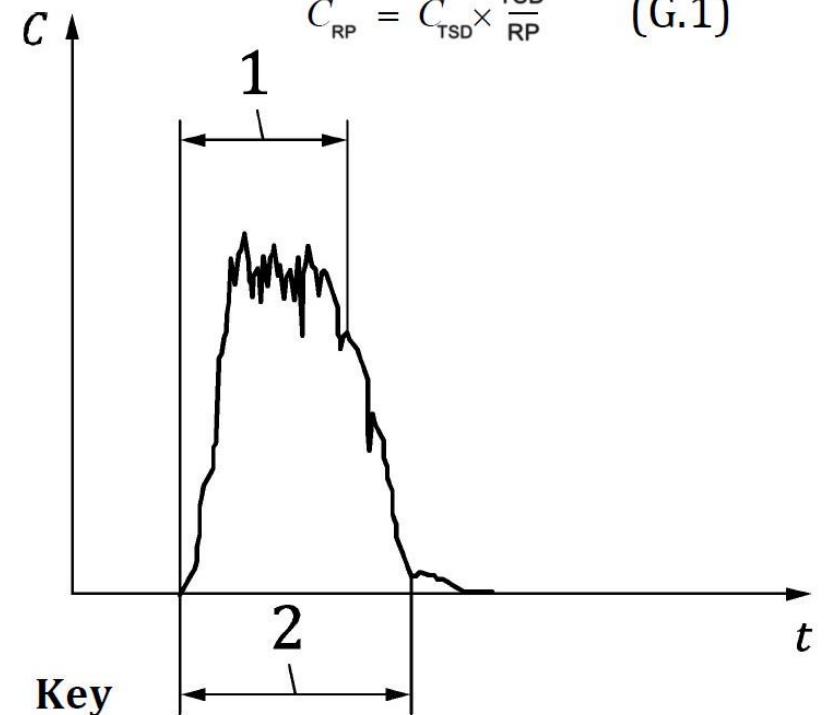
Key

1	TSD = RP
C	exposure concentration
2	task
t	time

Figure D.7

Combined Annex G and D.3 b)
Tasks and sampling duration (TSD) longer than the reference period (RP) of the OELV (shift or short term)

$$C_{RP} = C_{TSD} \times \frac{TSD}{RP} \quad (G.1)$$



Key

1	RP
C	exposure concentration
2	TSD = task
t	time

Introducing: IH-Aligner v 9.3.4-light

Automatisch opslaan ☐ Home Save Undo Redo Print ... IH-AI

G6 0%

	A	B	C	D	E	F	G
1		<u>Explanation</u>	IH-Aligner				Versie: 9.3.4-light
2		Sampled substance					20-11-2023
3		OELV		<make choice>			
4		Reference period OELV (Rp)	<make choice>				
5		Daily Exposure duration SEG (If appropriate, change the default 480)				Personal Air Sampling method	specify
6						Relative expanded Uncertainty (%) EN482 (2021) 6.1. g formula (4) & Annex B ISO-IEC Guide98-3 (2008)	0%

IH-Aligner deals with differences between sampling, task and OELV duration

Calculating the correct TWA for exposure

Example 1

Shift duration 8 hours = sampling time

Explanation	IH-Aligner			Person / Group / ID	C ₅ OELV?	C ₅ +Extended Uncertaintysf(OELV)? - n<=3: 10% OELV - n=4: 15% OELV - n=5: 20% OELV
Sampled substance	Heptane (Paul Hewett) [AIHA-2015 4e edition] (TLV TWA US)			04-06-2024		
OELV	400,00	ppm				

	Date	Person / Group / ID	Measured concentration in ppm (< sign before value in case of concentration below LoQ)	Total Sampling Duration (TSD) (minutes). Default 480	Worker's Exposure time t (minutes). Default 480	SEG Daily exposure duration or Workers Exposure time (t) (minutes)	Workers Concentration C(Rp) aligned to the OELV Reference period (Rp) (red cell > OELV)	Workers Concentration C(Rp) as % of 400 ppm 8 hours - green cell <= OELV - red cell > OELV
1	01-01-2021	worker1	124,000	480		480,00	124,00	31%
2	01-02-2021	worker1	63,000	480		480,00	63,00	15,8%
3	01-03-2021	worker1	274,000	480		480,00	274,00	68,5%
4	01-04-2021	worker2	44,000	480		480,00	44,00	11%
5	01-05-2021	worker2	8,000	480		480,00	8,00	2%

	Date	Person / Group / ID	Measured concentration in ppm (< sign before value in case of concentration below LoQ)	Total Sampling Duration (TSD) (minutes). Default 480	Worker's Exposure time t (minutes). Default 480	Daily exposure duration or Workers Exposure time (t) (minutes)	Concentration C(Rp) aligned to the OELV Reference period (Rp) (red cell > OELV)	C(Rp) as % of 400 ppm 8 hours - green cell <= OELV - red cell > OELV
1	01-01-2021	worker1	124,000	480		480,00	124,00	31%
2	01-02-2021	worker1	63,000	480		480,00	63,00	15,8%
3	01-03-2021	worker1	274,000	480		480,00	274,00	68,5%
4	01-04-2021	worker2	44,000	480		480,00	44,00	11%
5	01-05-2021	worker2	8,000	480		480,00	8,00	2%

Example 2

Shift duration 8 hours = sampling time < 8 hours

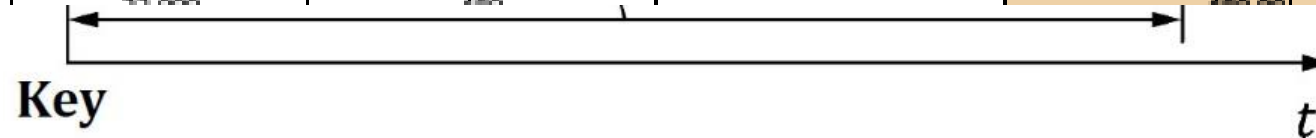
Annex D. a) Workplace factors are constant during the full work shift (WS)

Measure during one or more periods of exposure

Total sampling duration (TSD_{min}) should be a minimum of 2 hours

Exposure of the sampling period $C(TSD_{min})$ = the full work shift exposure C_{ws}

	Date	Person / Group / ID	Measured concentration in ppm (< sign before value in case of concentration below LoQ)	Total Sampling Duration (TSD) (minutes). Default 480	Worker's Exposure time t (minutes). Default 480	SEG Daily exposure duration or Workers Exposure time (t) (minutes)	Workers Concentration C(Rp) aligned to the OELV Reference period (Rp) (red cell > OELV)	Workers Concentration C(Rp) as % of 400 ppm 8 hours - green cell <= OELV - red cell > OELV	
1	01-01-2021	worker1	124,000	120		480,00	124,00	31%	
2	01-02-2021	worker1	63,000	240		480,00	63,00	15,8%	
3	01-03-2021	worker1	274,000	180		480,00	274,00	68,5%	
4	01-04-2021	worker2	44,000	360		480,00	44,00	11%	
5	01-05-2021	worker2	8,000	420		480,00	8,00	2%	



C exposure concentration

t time

2 TSD_{min} = 2 h

3 and 4 TSD_{min} = 1 h+1 h

5 WS

Figure D.1

Example 3

Shift duration 8 hours = exposure time 2 hours (3)

Annex D. b) Workplace factors are not constant during the full work shift (WS)

1) Exposure occurs during a part of shift

	Date	Person / Group / ID	Measured concentration in ppm (< sign before value in case of concentration below LoQ)	Total Sampling Duration (TSD) (minutes). Default 480	Worker's Exposure time t (minutes). Default 480	SEG Daily exposure duration or Workers Exposure time (t) (minutes)	Workers Concentration C(Rp) aligned to the OELV Reference period (Rp) (red cell > OELV)	Workers Concentration C(Rp) as % of 400 ppm 8 hours - green cell <= OELV - red cell > OELV
1	01-01-2021	worker1	124,000	120		120,00	31,00	7,8%
2	01-02-2021	worker1	63,000	120		120,00	15,75	3,9%
3	01-03-2021	worker1	274,000	120		120,00	68,50	17,1%
4	01-04-2021	worker2	44,000	120		120,00	11,00	2,8%
5	01-05-2021	worker2	8,000	120		120,00	2,00	0,5%

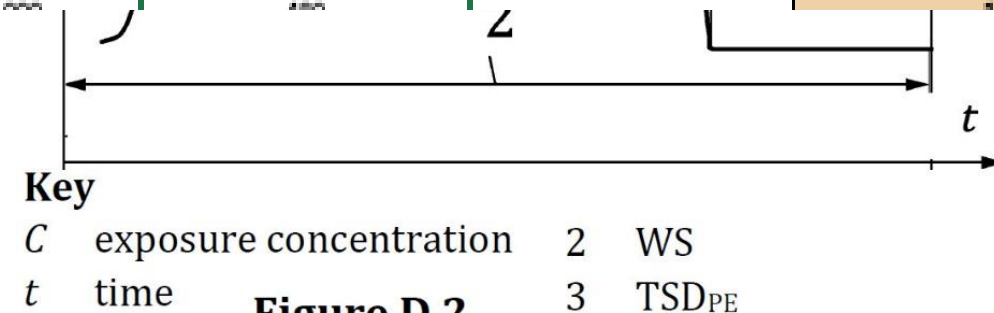


Figure D.2

Example 4

Shift duration 12 hours = sampling time

Annex D : Exposure pattern, OELV reference period and sampling duration

Total Sampling Duration (TSD_{max}) applies for the full work shift (WS)

TSD_{max} = WS = OELV_{ref}. And therefore C₁=C₅ should not exceed OELV

	Date	Person / Group / ID	Measured concentration in ppm (- sign before value in case of concentration below LoQ)	Total Sampling Duration (TSD) (minutes). Default 480	Worker's Exposure time t (minutes). Default 480	SEG Daily exposure duration or Workers Exposure time (t) (minutes)	Workers Concentration C(Rp) aligned to the OELV Reference period (Rp) (red cell > OELV)	Workers Concentration C(Rp) as % of 400 ppm 8 hours - green cell <= OELV - red cell > OELV	C
1	01-01-2021	worker1	124,000	720		720,00	186,00	46,5%	
2	01-02-2021	worker1	63,000	720		720,00	94,50	23,6%	
3	01-03-2021	worker1	274,000	720		720,00	411,00	102,8%	
4	01-04-2021	worker2	44,000	720		720,00	66,00	16,5%	
5	01-05-2021	worker2	8,000	720		720,00	12,00	3%	

Key

C exposure concentration
t time

1 TSD_{max} = WS
5 WS

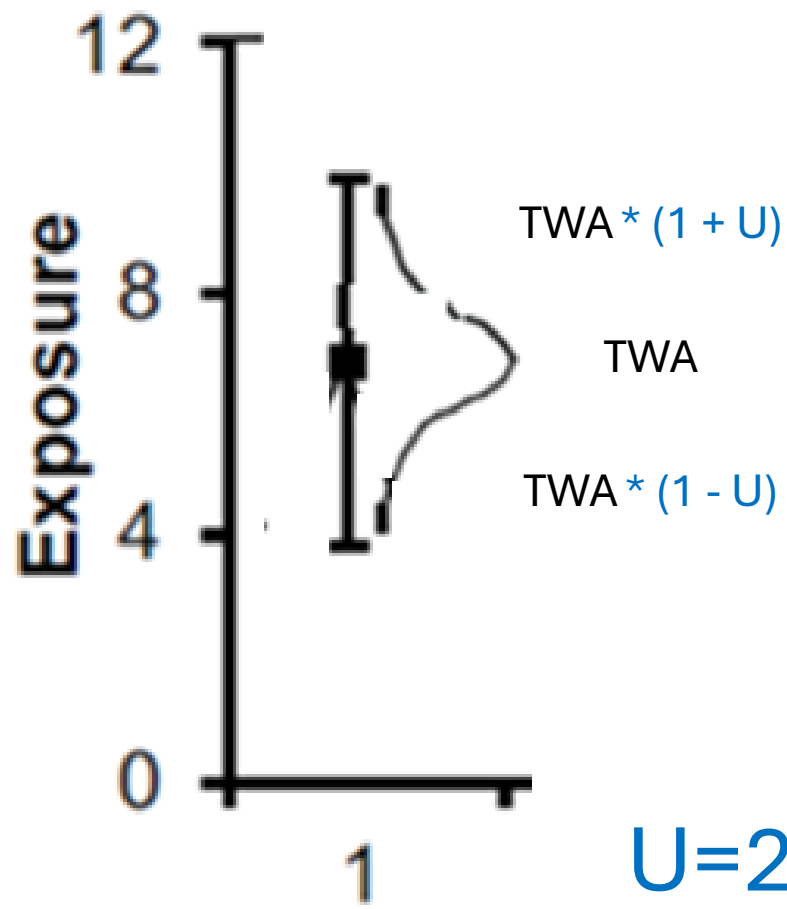
t

SEG validation using sampling

Purple is basic characterisation

1. Identify the SEG to profile.
 - Stratify workers and time periods (maximise variability) or
 - Select randomly workers and random time periods.
2. Perform sampling.
3. Determine if the data fits a lognormal or normal distribution.
4. Determine overall and subgroup compliance
5. Make a decision on validity of the exposure profile and the SEG.
6. Refine the SEG if necessary.

Measurement uncertainty U



$$U = 2 * CV_T$$

INTERNATIONAL
STANDARD

**ISO
20581**

First edition
2016-11-01

EUROPEAN STANDARD

EN 482

NORME EUROPÉENNE

EUROPÄISCHE NORM

March 2021

**Workplace air — General
requirements for the performance of
procedures for the measurement of
chemical agents**

*Air des lieux de travail — Exigences générales concernant les
performances des procédures de mesure des agents chimiques*

U = Expanded uncertainty

EN-482 (2021) EN 5.4.6 Tabel 1 Expanded uncertainty requirements for measurements for comparison with limit values and periodic measurements

Reference period	Measuring range	Relative expanded uncertainty
short-term (for example, 15 min)	0,5 times to 2 times limit value	$\leq 50 \%$
long-term	0,1 times to < 0,5 times limit value	$\leq 50 \%$
long-term	0,5 times to 2 times limit value	$\leq 30 \%$

IH-Aligner deals with measurement uncertainty

- individual measurement compliance tests
- action level tests
- preliminary, screening tests (3 to 5 measurements)