



Advancing Worker Health Protection

9th - 13th June | Aviva Stadium | Dublin

3. Use of exposure models Interpretation of results

(AIHA 4th edition, EN689 clause 5.1).

NVvA 2024 – PBC Woudschoten 9-4-2024

IOHA 2024 – PDC-150 Dublin 9-6-2024

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Workplace air exposure modelling

- **Hybrid**

- **Trexmo hub (Free)**

- ART 1.5 based (Free)
 - Stoffenmanager® V4 (Free)
 - ECETOC TRA v3 (Free)

- **Stand-alone higher versions**

- Stoffenmanager® V8 (Free/Paid)
 - ECETOC TRA v3.2 (Free)

- **Mathematical AIHA IHMOD (Free)**



Mathematical Models AIHA IHMOD 2.0



Exposure Assessment
Strategies Committee

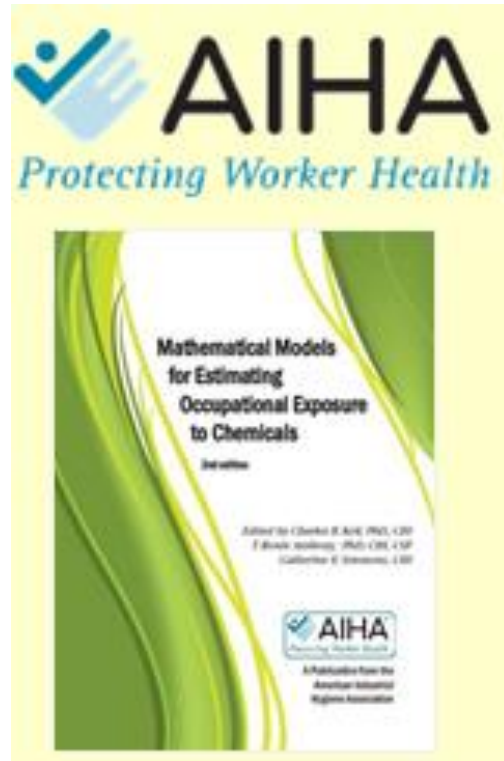
IH Mod 2.0



Deterministic



Monte Carlo



Version 2.016, June 2023

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3. Models PDC-150 IOHA 2024 Dublin, vanBaten, Schreijers &

Emonds

This file has been created by Daniel Drolet and Tom Armstrong with review by Michael Jayjor

| | HELP | HELP |
|--|------|------|
| 1 Well-Mixed Room Model | | |
| 2 Well-Mixed Room Model with Backpressure | | |
| 3 Well-Mixed Room Model Purging Equation | | |
| 4 Well-Mixed Room Model Decreasing Emission Rate, Spill Model | | |
| 5 Turbulent Eddy Diffusion without Advection following a Pulse Release | | |
| 6 Turbulent Eddy Diffusion without Advection with a Constant Emission Rate | | |
| 7 Turbulent Eddy Diffusion with Advection following a Pulse Release | | |
| 8a Two-Zone Model with a Constant Emission Rate | | |
| 8b Two-Zone Mode with a Decreasing Emission Rate | | |
| 10 Turbulent Eddy Diffusion with Advection with a Constant Emission Rate | | |
| 11 Near and Mid - Field Plume Models | | |

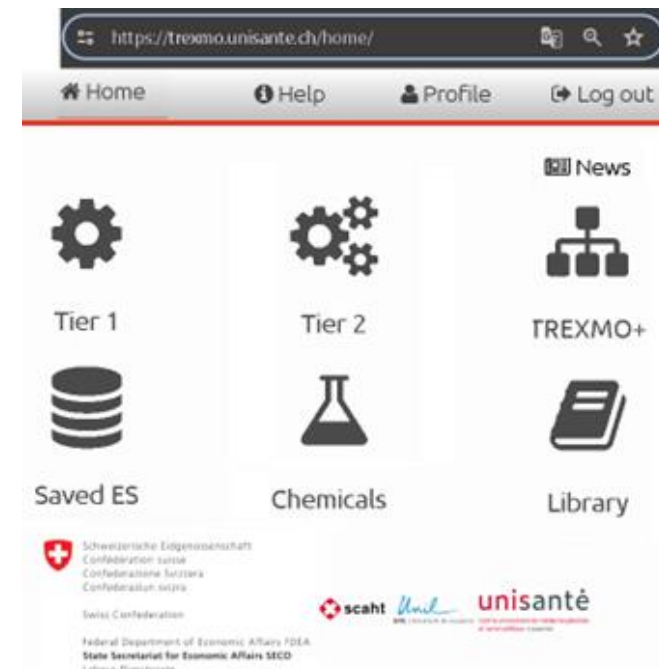
09/06/2024 09:00-12:30

3

Trexmo hybride exposure modelling hub

<https://trexmo.unisante.ch/home/>

- **Advanced REACH TOOL (ART)** *Warning! Model is optimised for 480 minute exposure period.
- **Stoffenmanager® (v4; 2010)**
- **ECETOC TRA v3**
- 'Metals' EASE (MEASE)
- EMGK-EXPO-TOOL
- EASE 2



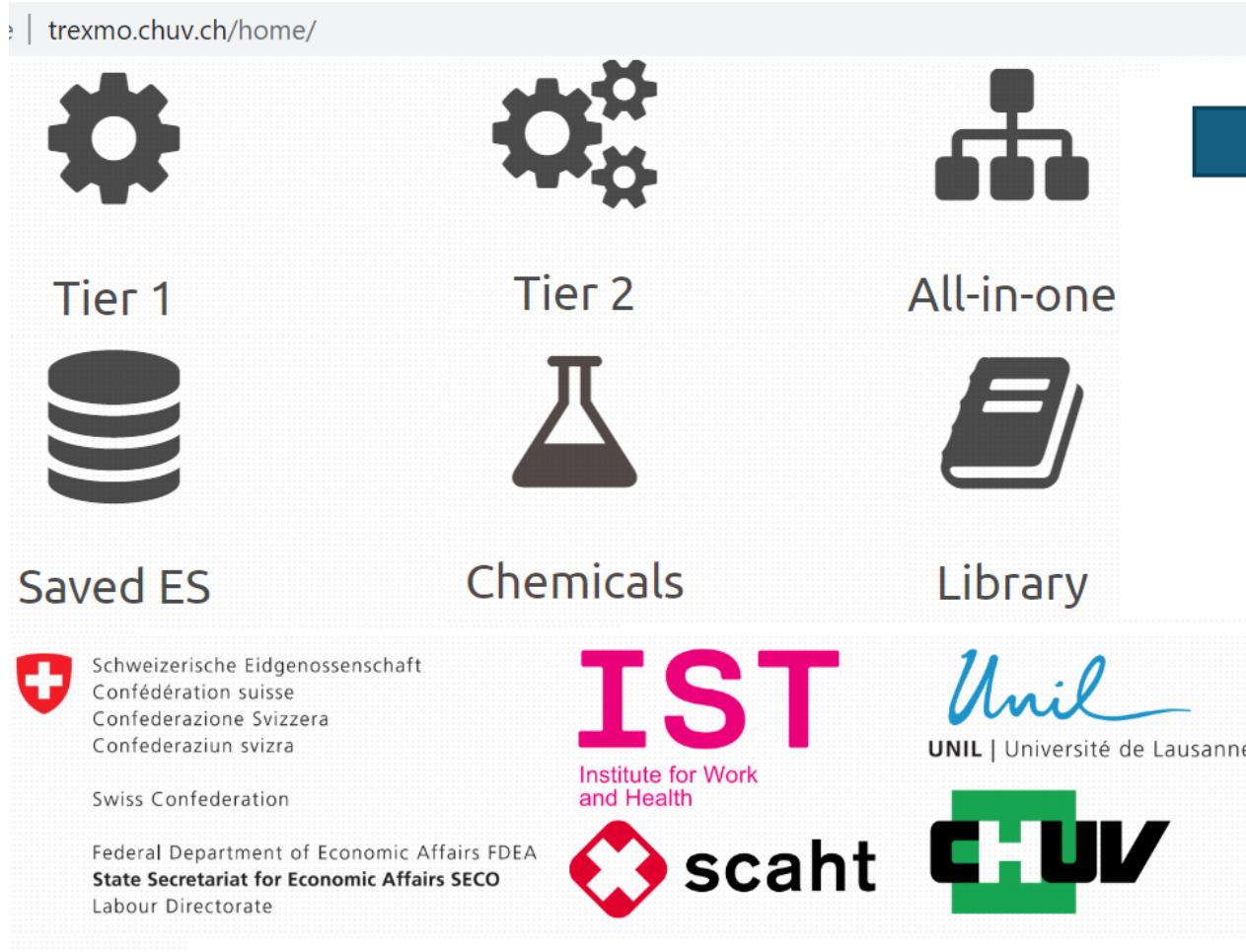
| The domains of applicability of the six models of TREXMO | | | | | | |
|--|-----------------------------|------------------------------|-----------------------------------|--------------------|----------------------|--------|
| | Dusts (non- abrasive) | Solids (abrasive dust) | Fumes (hot-work techniques) | Mists (≤ 10 Pa) | Vapours (> 10 Pa) | Gasses |
| ART | Green | Green | Red | Green | Green | Red |
| Stoffen- manager | Green | Green | Red | Green | Green | Red |
| ECETOC TRAv3 | Green | Yellow | Red | Yellow | Green | Red |
| MEASE | Green | Green | Green | Green | Green | Green |
| EMKG- EXPO- TOOL | Green | Red | Red | Red | Red | Red |
| EASE 2 | Green | Green | Red | Red | Red | Green |

Green: applicable Yellow: partly applicable Red: not applicable

3. Models FDC-150 IOHA 2024 Dublin. vanBalen, Scheffers & Emonds

Trexmo hybrid exposure model hub

<http://trexmo.chuv.ch>



- ART
- MEASE
- Stoffenmanager
- EMKG-EXPO-TOOL
- ECETOC TRA v3
- EASE



Trexmo⁺ / ART

Information on Workplace factors (1. Source)

- Product-type of substance/preparation
 - Powders, granules or pelletized material
 - Dustiness
 - Weight fraction (0-1)
 - Moisture content
 - Solid objects
 - Weight fraction (0-1)
 - Moisture content
 - Liquids
 - Vapour pressure (max 100000 Pa)
 - Molecular Weight (g/mol)
 - Powders dissolved in a liquid matrix
 - Weight fraction
 - Molecular weight
 - Viscosity of substance
 - Paste slurry or clearly (soaked) wet powder
 - Paste/slurry potentially contaminated with powdered material
 - Dustiness
 - Weight fraction (0-1)
- Source distance from workers breathing zone (mouth and nose)
 - < 1 metre
 - > 1 metre
- Secondary sources present at workplace
 - Yes
 - No
- Surface contamination \ fugitive emission sources
 - Default level
 - General housekeeping practices
 - Demonstrable and effective housekeeping
 - Process fully enclosed (air tight)

Trexmo⁺ / ART

Information Workplace factors (2. Activity)

- Activity Class
- Situation which best represents activity
- Level of agitation
- Level of contamination
- Process category (PROC)
- Type of settings
- Task duration (0-480 min)

Trexmo⁺ / ART

Information Workplace factors (3. Controls)

- Localized controls-primary
- Technique of applied primary localized controls
- Localized controls-secondary
- Exposure site
- Ventilation rate
- Workplace volume
- Segregation of the source

TREXMO⁺ / ART Powders

Source ✓

Product type of the substance/preparation

Powders, granules or pelletized material

Dustiness

Fine dust

Weight fraction (0-1)

0,5

Moisture content

Dry product (< 5% moisture content)

Source distance from the worker's breathing zone (mouth and nose)

Less than 1 metre (near-field zone)

Secondary sources present at workplace

Yes

Surface contamination / Fugitive emission sources

Default level (no specific cleaning practices, no pro

Activity ✓

Activity Class

Moving and agitation of powders, granules or pelle

Situation which best represents activity

Movement and agitation of 10-100 kg

Level of agitation

Other handling with high level of agitation

Level of contamination

Open process

Process category (PROC)

(R) PROC 5: mixing or blending in batch processes (

Type of settings

Industrial

Task duration (0-480 min)

480

Controls ✓

Localized controls - primary

Suppression techniques

Technique of applied primary localized controls

Wetting at the point of release

Localized controls - secondary

No localized controls

Exposure site

Indoors

Ventilation rate

Only good natural ventilation

Workplace volume

300 m3

Segregation of the source

No segregation

TREXMO⁺ / ART Liquids

(Vapour Pressure < 11 Pa)

Source ✓

Product type of the substance/preparation

Liquids

Vapour pressure (max 100 000 Pa)

10

Weight fraction (0-1)

0.5

Molecular Weight (g/mol)

100

Viscosity of substance

Liquids with low viscosity (like water)

Source distance from the worker's breathing zone (mouth and nose)

Less than 1 metre (near-field zone)

Secondary sources present at workplace

Yes

Surface contamination / Fugitive emission sources

Default level (no specific cleaning practices, no pro

Activity ✓

Activity Class

Spreading of liquid products

Situation which best represents activity

Spreading of liquids at surfaces or work pieces 0.3-

Process category (PROC)

(R) PROC 10: roller application or brushing

Type of settings

Industrial

Task duration (0-480 min)

480

Controls ✓

Localized controls - primary

Local Exhaust Ventilation

Technique of applied primary localized controls

Other receiving hoods

Localized controls - secondary

Local Exhaust Ventilation

Technique of applied primary localized controls

On-tool extraction

Exposure site

Indoors

Ventilation rate

Only good natural ventilation

Workplace volume

300 m3

Segregation of the source

No segregation

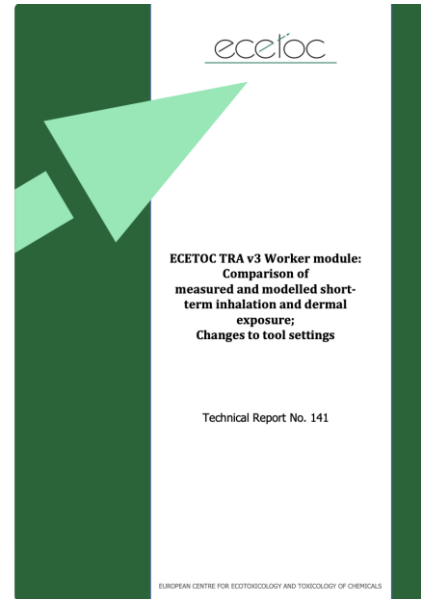
TREXMO⁺ / ART Liquids (Vapour Pressure > 10 Pa)

| Source ✓ | Activity ✓ | Controls ✓ |
|--|---|--|
| Product type of the substance/preparation Liquids | Activity Class Spreading of liquid products | Localized controls - primary Local Exhaust Ventilation |
| Vapour pressure (max 100 000 Pa) 1000 | Situation which best represents activity Spreading of liquids at surfaces or work pieces 0.3-' | Technique of applied primary localized controls Other receiving hoods |
| Mole fraction (0-1) 0.5 | Process category (PROC) (R) PROC 10: roller application or brushing | Localized controls - secondary Local Exhaust Ventilation |
| Molecular Weight (g/mol) 100 | Type of settings Industrial | Technique of applied primary localized controls On-tool extraction |
| Activity coefficient of substance (0-40) 1 | Task duration (0-480 min) 480 | Exposure site Indoors |
| Source distance from the worker's breathing zone (mouth and nose) Less than 1 metre (near-field zone) | | Ventilation rate Only good natural ventilation |
| Secondary sources present at workplace Yes | | Workplace volume 300 m3 |
| Surface contamination / Fugitive emission sources Default level (no specific cleaning practices, no pro | | Segregation of the source No segregation |

PROCs

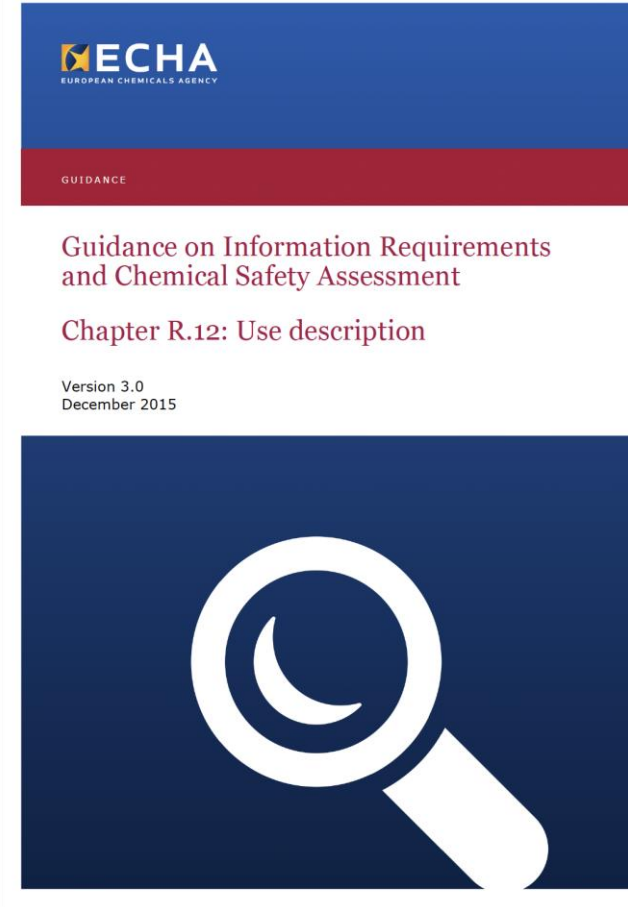
ECETOC TRA lookup J:K

| PROCs | PROC description |
|--------|---|
| PROC1 | 1 - Use in closed process, no likelihood of exposure |
| PROC2 | 2 - Use in closed, continuous process with occasional controlled exposure |
| PROC3 | 3 - Use in closed batch process (synthesis or formulation) |
| PROC4 | 4 - Use in batch and other process (synthesis) where opportunity for exposure arises |
| PROC5 | 5 - Mixing or blending in batch processes (multistage and/or significant contact) |
| PROC6 | 6 - Calendering operations |
| PROC7 | 7 - Industrial spraying |
| PROC8a | 8a - Transfer of chemicals from/to vessels/ large containers at non dedicated facilities |
| PROC8b | 8b - Transfer of chemicals from/to vessels/ large containers at dedicated facilities |
| PROC9 | 9 - Transfer of chemicals into small containers (dedicated filling line) |
| PROC10 | 10 - Roller application or brushing |
| PROC11 | 11 - Non industrial spraying |
| PROC12 | 12 - Use of blow agents for foam production |
| PROC13 | 13 - Treatment of articles by dipping and pouring |
| PROC14 | 14 - Production of preparations or articles by tableting, compression, extrusion, pelletisation |
| PROC15 | 15 - Use of laboratory reagents in small scale laboratories |
| PROC16 | 16 - Using material as fuel sources, limited exposure to unburned product to be expected |
| PROC17 | 17 - Lubrication at high energy conditions and in partly open process |
| PROC18 | 18 - Greasing at high energy conditions |
| PROC19 | 19 - Hand-mixing with intimate contact (only PPE available) |
| PROC20 | 20 - Heat and pressure transfer fluids (closed systems) in dispersive use |
| PROC21 | 21 - Low energy manipulation of substances in materials and/or articles |
| PROC22 | 22 - Potentially closed operations with minerals at elevated temperature |
| PROC23 | 23 - Open processing and transfer of minerals at elevated temperature |
| PROC24 | 24 - High (mechanical) energy work-up of substances bound in materials and/or articles |
| PROC25 | 25 - Hot work operations with metals |



PROCs

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Execution TREXMO⁺ step 1: substance

Browser address bar: <https://trexmo.unisante.ch/home/>

Navigation: Home | Help | Profile | Log out

Icons: Tier 1, Tier 2, TREXMO+, Saved ES, Chemicals, Library

Logos: Swiss Confederation, scaht, unil, unisante

Text: Federal Department of Economic Affairs FDEA, State Secretariat for Economic Affairs SECO, Labour Directorate

Navigation: Home | lp | Profile | Log out

My Chemicals

Chemicals [+ Add New](#)

| Name | CAS | Mol. formula | IUPAC Name | MW [g/mol] | DNEL [mg/m ³] | Delete |
|------|-----|--------------|------------|------------|---------------------------|--------|
|------|-----|--------------|------------|------------|---------------------------|--------|

| Chemicals | |
|--|---|
| Display Name: | Volatile Organic Solvent (VOS) |
| CAS number | 64742-82-1 |
| Formula | C _n H _m |
| IUPAC name: | C ₆₋₁₂ complex hydrocarbon mixture |
| Molecular weight (g/mol) | 100 |
| DNEL: SCOEL 087 mg/m ³ /8hr | 116 |

Navigation: Home

My Chemicals

Chemicals

Display Name:

CAS number:

Molecular formula:

IUPAC name:

Molecular weight (g/mol):

Derived no-effect limit (DNEL), mg/m³:

Execution TREXMO+ step 2: define scenario

https://trexmo.unisante.ch/home/

Home

Help

Profile

Log out

Tier 1

Tier 2

TREXMO+

Saved ES

Chemicals

Library

Schweizerische Eidgenossenschaft
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Swiss Confederation

UNIL | Université de Lausanne

Centre universitaire de médecine générale
et santé publique - Lausanne

Federal Department of Economic Affairs FDEA
State Secretariat for Economic Affairs SECO
Labour Directorate

Source

Activity

Controls

Product type of the substance/preparation

Source distance from the worker's breathing zone (mouth and nose)

Surface contamination / Fugitive emission sources


Task duration (0-480 min)


| My Trexmo+ scenario Group # | 1 mobile | 2 mechanical ventilation | 3 full enclosure | 4 LEV |
|-----------------------------|----------|--------------------------|------------------|-------|
| | | | | |


Source


Execution TREXMO⁺ step 3: Run


All-in-one


 Home


 Help

 Log out


 My ES


 Save as


 Save

 Reset

ES Name: **Excercise 2**

Source 



Activity 

Controls 

Product type of the substance/preparation

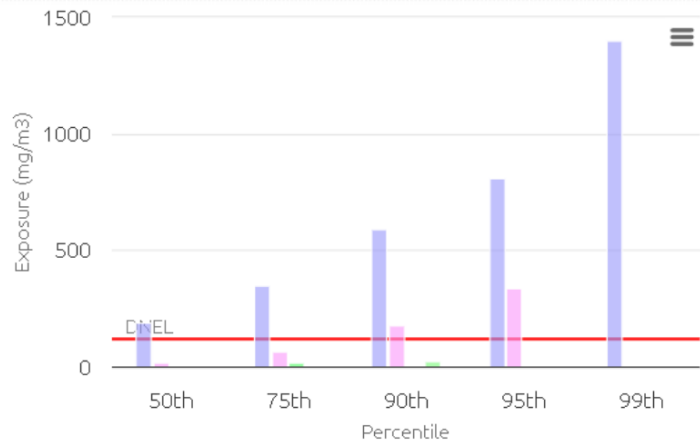
Activity Class

Localized controls - primary

 **Run**

What is your Basic Characterisation conclusion: BC<<OELV, BC>>OELV or otherwise?

Exposure Predictions for ES: "Exercise 2"



Plot DNEL for:

Volatile Organic Solvent (VOS), DNEL (mg/m³): 116.0

ECETOC TRA v3: C75%

15 mg/m³

MEASE: ~C90%

26 mg/m³

Advanced REACH Tool (ART) [mg/m³]

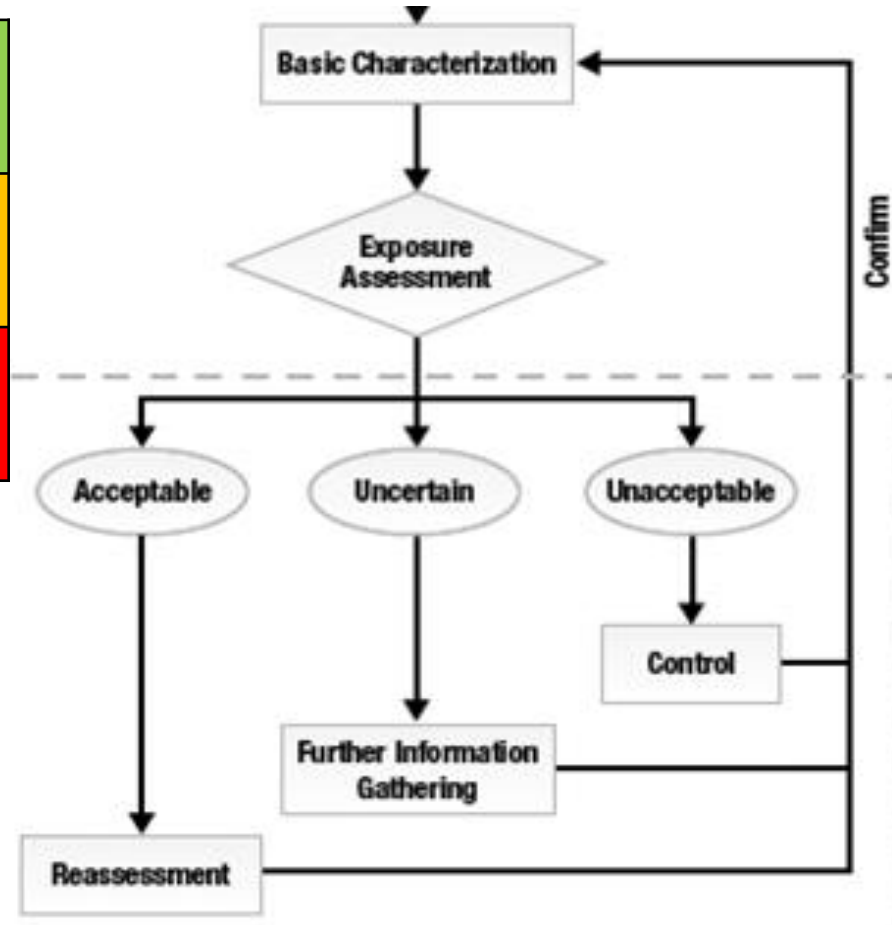
| Percentile | Exposure | IQ CI | 80% CI | 90% CI | 95% CI |
|------------|----------|----------|----------|----------|----------|
| 50th | 190 | 99-370 | 55-670 | 39-930 | 29-1300 |
| 75th | 350 | 180-700 | 98-1300 | 68-1900 | 51-2800 |
| 90th | 590 | 290-1300 | 160-2600 | 110-4200 | 79-6900 |
| 95th | 810 | 390-1800 | 200-3900 | 140-6800 | 100-10e3 |
| 99th | 1400 | 650-3400 | 330-8700 | 230-10e3 | 160-10e3 |

Stoffenmanager [mg/m³]

| Percentile | Exposure |
|------------|----------|
| 50th | 20 |
| 75th | 64 |
| 90th | 180 |
| 95th | 338 |

| | |
|------------|----------------|
| BC << OELV | Compliance |
| Otherwise | more BC or PAS |
| BC >> OELV | Non-compliance |

EN-689 2018 §5.1.5



AIHA 4th edition 2015

Exercise 2 Exposure modelling spray painting VOS using TREXMO⁺

1. mobile



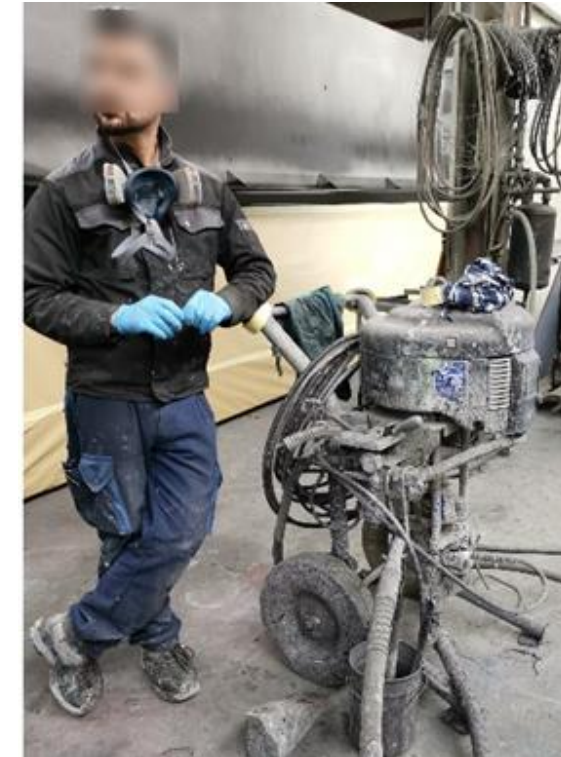
2. mech. vent.



3. full enclosure



4. LEV



Example:

Use of models for dust-exposures

Inhalable dust from mechanical
machining railway ballast

Exposure to inhalable dust from railway ballast

TNO 2023

Chain hor



Stopmachine



Profiling machine



Mechanical machining of railway ballast

Trexmo+ (OEL inhalable dust is 4 mg/m³)

ES Name: **Mechanische bewerking ballast vochtigheid 5%**

Source ✓

Product type of the substance/preparation

Solid objects

Weight fraction (0-1)

0,35

Moisture content

Dry product (< 5% moisture content)

Distance from the work breathing zone (head and nose)

Less than 1 metre (near-field zone)

Secondary sources present at workplace

No

Surface contamination / Fugitive emission sources

Default level (no specific cleaning practices, no pro

Activity ✓

Activity Class

Fracturing and abrasion of stone objects

Situation which best represents activity

Mechanical treatment / abrasion of small-sized surf

Level of contamination

Open process

Process category (PROC)

(R) PROC 24c: high (mechanical) energy work-up of

Type of settings

Industrial

Task duration (0-480 min)

480

Controls ✓

Localized controls - primary

No localized controls

Exposure site

Outdoors

Distance of exposure source from building

Far from buildings

ART P90 (CI 90%):

39 (5.3-680) mg/m³

Stoffenmanager* P90:

59 mg/m³

ECETOC TRAv3:

0.7 mg/m³

MEASE:

n.a. mg/m³

EMKG-EXPO-TOOL:

n.a. mg/m³

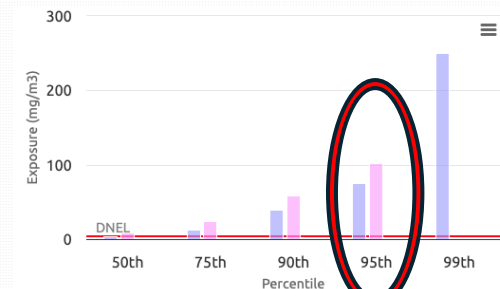
EASE:

n.a. mg/m³

n.a.: non-applicable ES

TREXMO uses the algorithm of Stoffenmanager® version 4.0 that was published in a peer reviewed article (Schinkel et al., 2010*). The most recent version of Stoffenmanager® can be found at www.stoffenmanager.nl. Note that exposure predictions calculated in TREXMO based on Schinkel et al. (2010) may therefore differ from the predictions calculated with newer versions of Stoffenmanager®.

*Schinkel J., Fransman W., Heussen H., et al. (2010) Cross-validation and refinement of the Stoffenmanager as a first tier exposure assessment tool for REACH. Occup Environ Med, 67 (Suppl 1): i25-i32.



Plot DNEL for:

Inhalable dust, DNEL (mg/m3): 4.0

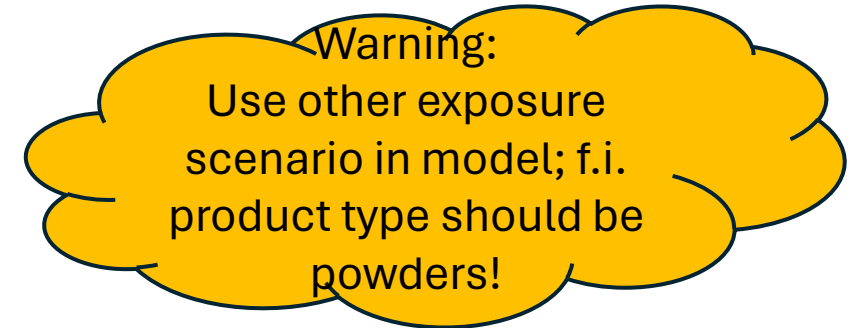
Influence of moisture (spraying is the most important control measure)

mg/m³ | 95th percentile | (ART IQ CI)

| Moisture | Stoffenmanager | ART | ART (25-75% CI) |
|----------|----------------|-----|------------------|
| < 5% | 102 | 73 | 28- 240 |
| 5-10% | 102 | 22 | 8,4- 72 |
| >10 % | 102 | 2,1 | 0,81- 6,9 |

Comparison ART model (<5% moisture content) mechanical machining with actual measurements

mg/m³ | ART IQ CI | PAS machines min-max



| Distance (m) | ART (95%-tile) | ART (25-75% CI) | Measurements (TNO) | | | Profiling- machine with brush |
|--------------|-------------------|--------------------|--------------------|-----------------|-----------------------------------|-------------------------------------|
| | | | Chain hor | Stop machine | Profiling- machine no brush | |
| 1 - 4 | 1,8 | 0,7- 6,1 | 0,4 – 10,28 | 0,63 – 1,34 | 1,58 – 4,36 | 21,1 – 37,3 |
| > 4 | 0,62 | 0,23- 2,0 | | | | |