Generic quantitative models for prediction of occupational exposure to respirable dust and respirable quartz within the formulating, metal manufacturing and construction industries

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20th March 2024

ISES 2024, Berlin

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Introduction

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Get to know Stoffenmanager®

Stoffenmanager® is a knowledge-based platform aimed at reducing exposure risks to hazardous substances and biological agents in the workplace. We offer a sustainable and simple solution to help organizations meet regulatory requirements and to be responsible employers by creating a safe workplace. We do this by means of consultancy, training courses and the scientifically validated tool, Stoffenmanager® version 8. Together with you, we work on a safe and healthy work environment!

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Stoffenmanager® is an online system to identify the chemical hazards, control the exposure at workplaces and communicate in an understandable, transparent manner to managers, employees and external stakeholders.

News

Background

Health effects

- Occupational exposure to respirable quartz can lead to a variety of pulmonary diseases including **silicosis** and **lung cancer**
- Crystalline silica in the form of quartz (or cristobalite) dust is **carcinogenic to humans** (Group 1) *(ref: IARC Monograph vol. 68 (1997); vol. 100C (2009))*
- Long-term exposure to metallic particles may cause **impairment of pulmonary surfactant** and **lung function** and result in **chronic respiratory diseases**

Aim of the project

- The **current version** of Stoffenmanager® is **not applicable** to all areas of activity with solids in which **dusty hazardous substances** are used or may arise.
- Expanding the applicability domain of Stoffenmanager® by **developing three innovative quantitative algorithms**

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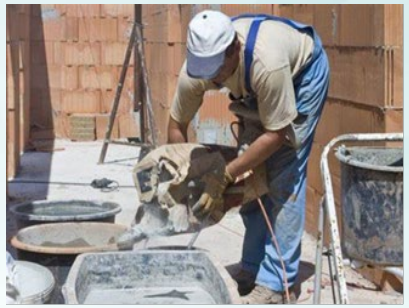
Exposure Modelling: development of **new** quantitative algorithms

A close collaboration between Stoffenmanager® and IFA / DGUV

1. Tasks with dusty products for **respirable dust and respirable quartz** (Alg. 1)



2. **Respirable dust** for metal-cutting manufacturing (Alg.2)

3. Mechanical processing of stone for **respirable dust and respirable quartz** (Alg. 3)

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Coding Process

- For each new algorithm, a **coding procedure** was created. In this document it is stated how information from IFA MEGA database can be coded as Stoffenmanager® input parameters.
- Based on the contextual information, Stoffenmanager (dimensionless) **scores** were assigned by researchers independently
- Most parameters are divided **into classes** with scores on a logarithmic scale
- The higher **the score**, the higher **the potential exposure**

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Table 1. Scores for intrinsic emission of solids

Intrinsic emission parameter	Explanation	Score
Solid objects	Solid forms of substances or products, such as blocks, kegs or slabs	0
Firm granules or flakes	For example, firm polymer granules, granules covered with a layer of wax, bound fibres, such as in cotton. No dust emission without intentional breakage of the product	0.01
Granules or flakes	Granules or flakes that may fall apart and crumble. For example, washing powder, sugar or fertilizer	0.03
Coarse dust	A dust cloud is formed, but settles quickly due to gravity. For example, sand, coarse carbon black, calcium stearate, unbound fibres	0.1
Fine dust	A dust cloud is formed that is clearly visible for some time. For example, talcum powder, flour	0.3
Extremely dusty products	A visible dust cloud remains airborne for a long time	1

Calibration and validation of the exposure models

- Stoffenmanager® scores were calculated in Stoffenmanager® MRV
- Data points were randomly divided into **60%** for the calibration and **40%** for the validation steps
  - ✓ **Imputation procedure** was used to account for exposure concentrations < LoD
  - ✓ **Cook's distance** analyses were performed to look for potential **leverage points** (outliers)
- Corresponding **measurement value** was assigned to each **calculated Stoffenmanager® score**
- **Spearman correlation** coefficients was calculated to study the relation between Stoffenmanager scores and measured exposure concentrations (**calibration dataset**)
- **M**ixed-**E**ffect **R**egression models were performed to predict a GM exposure level (Y) for a given Stoffenmanager score:

$$Y = EXP\ [\beta_0 + \beta_1 . Ln\ (C_t)]$$

- **Spearman correlation coefficients** was calculated to study the relation between concentration estimated, calculated with use of new regression equations, and measured exposure concentrations (**validation dataset**)
- **Proportions** of measurements exceeding the 50^{th} and 90^{th} percentiles were calculated

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Example: Mechanical processing of stone for respirable quartz

Workplace Exposure Scenario:

Process

Task (handling type):	Low energy mechanical handling of stone resulting in less dust
In the breathing zone:	yes
Multiple employees:	No
RPE's:	No
Duration (min):	60
Frequency:	4-5 days a week

Workplace

Working room size:	Volume 100- 1000 m³
Working room ventilation:	General ventilation (open windows and doors)
Regular cleaning:	Yes
Regular inspection:	Yes
Local control measures:	Specifically designed and maintained LEV
Employee in cabin:	The employee does not work in a cabin.

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$$C_t = [(E \cdot a) + (E \cdot H \cdot \eta_{lc} \cdot \eta_{gv\_nf}) + (E \cdot H \cdot \eta_{lc} \cdot \eta_{gv\_ff})] \cdot \eta_{imm}$$

$C_t = 0{,}1$

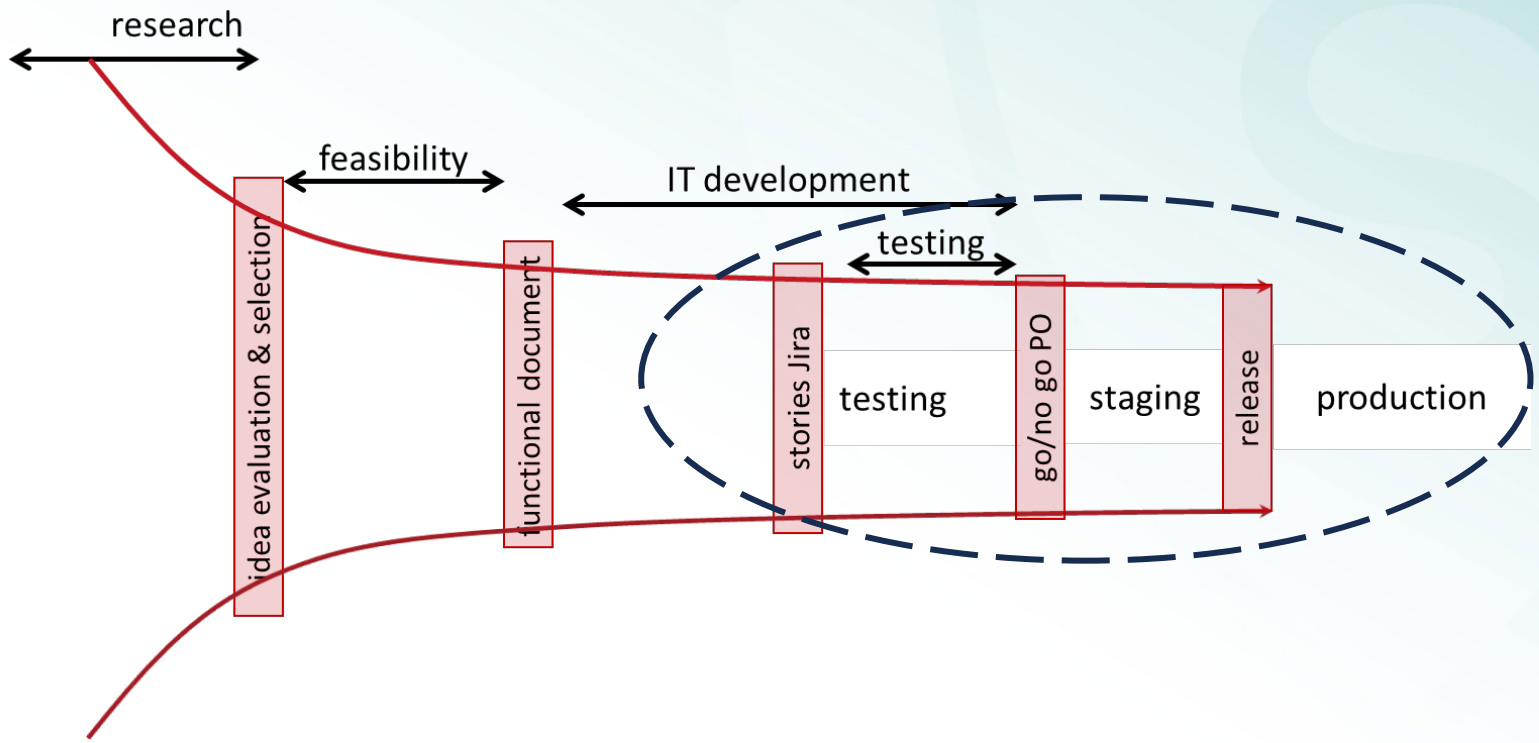
$GM = EXP\,[\beta_0 + \beta_1 . Ln\,(C_t)]$

$GM = 0{,}063\ mg/m^3$

Applicability domain Stoffenmanager®

Implementation of new quantitative algorithms in Stoffenmanager® and Gestis Stoffenmanager®:

- ✓ Substantial amount of personal exposure data used for the development of algortihms
- ✓ Good correlation
- ✓ Level of conservatism
- ✓ Implementation



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THANK YOU !

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