Sensors to assess and interpret exposure in construction industry

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Imagine....

- John
- 45 years old
- Works at a construction site
  - Silica, wood dust, welding fumes, diesel engine emissions
  - Some older colleagues are sick
- Employer
  - Understands health risks and performs yearly measurements (EN-689)
  - All measurements well below limits

- Why do people get sick?
- Are there any limitations in conventional measurements?
Conventional measurements vs sensors

Current workplace measurements
➢ Mainly TWA average measurements
➢ Standardised and accepted methods
➢ Directly comparable with OELs
➢ Limited number of measurements
➢ Labour intensive / expensive
➢ Typical exposure for SEG
➢ Results available after long time
➢ Retrospective general measures
➢ Measures on assumed causes

(Low-cost) Sensors
➢ High resolution data: exposure profile
➢ Sensors for limited number of substances
➢ Profile provides much information
➢ Rapidly much data
➢ User friendly, wearable, low-cost
➢ Individual exposure and feedback, awareness
➢ Data available in real time
➢ Real time intervention, personalised
➢ Data driven control measures
Can we benefit from sensors?

Advantages sensors:

• Many measurements for the same budget (individual differences and over time differences)
  → better identification of personal exposure situations
• More information on when exactly exposure takes place (easier interpretation)
  → better targeted control measures
• Results directly available (Real time risk management)
  → in time control

Disadvantages sensors:

• Sensors available for just a few substances (mainly PM)
• Price trade-off with accuracy
• Not (directly) comparable with OEL
Who we are and what we do

• TNO – exposure science department
• Team is working on new technologies for the prevention of occupational diseases
• Low cost sensors (LCS) for better interpretation of when, where and why exposure occurs to target preventive measures
  • How good are LCS?
  • What can LCS be used for (added values)?
  • How to operationally apply LCS to measure exposure?
  • (On site) sensor calibration
  • Actionable feedback (and to whom?)
  • Ethical and privacy concerns
  • Co-creation with Occupational Hygienists
  • Guidance documents

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Low cost PM sensors

- Developed for environmental monitoring
  - PM 2.5 and PM 10
  - Low concentrations (typical <50 ug/m3)
  - Mainly used stationary and continuously
  - Large variety in quality; price and accuracy are trade-offs

- For occupational application
  - Very important to check particle size and concentration range
  - Trend in most casus reliable; quantitative output moderately accurate
  - For occupational risk assessment specific compounds are relevant, like RCS, (hard) wood dust, welding fumes, DEE
Development of Chemical IDentifier

Device, inline with PM sensor, to determine fraction of CS in airborne dust

- Micro-cyclone, hollow waveguide, FTIR analyser.
- Can be used to analyse composition respirable dust
- Currently calibrated for CS only
- Not low cost
Focus group collaboration to develop and test

12 construction companies to define specs: questionnaires and meetings

• Exposure to CS is an issue at all companies; level of exposure in most cases unknown; more ‘dusts’ around than just CS

• Exposure is not measured; common knowledge is used to inform workers and decide on control measures (where and how)

• A more data driven approach is welcomed, but measurements alone is no solution

Companies want to use a RCS sensor to assess personal exposure and share feedback with the worker in traffic light colours

• Real time exposure profile

• Real time cumulative exposure

• Week overview

First field test with one of the members: Mateboer Groep

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Feedback on field test

- CID should be wearable
- Miniaturisation is possible

- Exposure profile alone is not sufficient to know what caused the exposure and where to target control measures
  - Interpretation necessary (peaks, activities, circumstances)
  - Combi with video (VEM) very useful but privacy sensitive
  - Alternative: use of context sensors
Casus miller: explain when, where and why exposure occurs

Sensors create exposure profiles; immediately clear *when* exposure takes place

Context information needed to identify *where* and *why*

- Context sensors to collect context information

Example case: construction worker (miller)

- Applying several machines (drill, milling machine, sledge hammer)
Selection of context sensors

• Context sensors: any technology that can provide context information in high time resolution (to be synced with exposure profile)

• Where based on indoor location tracking

• Why more difficult: first parameter selection based on source-receptor model.

• With focus group agreed to
  • Construction worker uses multiple machines: on/off? → vibration sensor
  • Exhaust connected to active machine: yes/no → proximity + vibration sensor
  • Proximity to other sources → proximity sensors
  • Work above head yes/no → orientation sensors underarm and machines
Focus group collaboration

Concept

Machine on

Exhaust connected

Work above head

Close to other sources

No exhaust

Above head

Other source

Background concentration

Machine off
Using sensors to create a healthy working environment (tno.nl)
UV sensor to determine which part of PM is welding fumes

Context sensors

PM2.5

UV vs welding torch current

Welding
Other activities
**Privacy and ethical concerns**

Workshop with stakeholders (2019):
- Without detailed understanding of the benefits, most stakeholders share a big brother is watching you feeling and think sensors are intrusive

Workshop with occupational hygienists (2022)
- ~90% see benefits in using sensors

Sentiment appears to be changing from ‘no, unless..’ into ‘yes, as long as…’

Main identified preconditions so far:
- Campaign wise application of sensors with clear and agreed goals between all involved (at least employer and employee) acceptable
- Sensor can not be deployed if there is any form of distrust between employer and employee
- Don’t collect more data than strictly required for the goal; participation voluntarily
- The usefulness must outweigh the burden
TNO’s 5 steps approach

1. Measure exposure
   • Measure exposure with (calibrated) sensors and use their benefits: more data, more informative data, real time data

2. Impact on health
   • More measurements provides better insights in who is exposed and the possibility of direct action prevents prolonged exposures

3. Source interpretation
   • By combining multiple data sources on our dataplatform EXCITE, it can be better and datadriven determined when, where and why exposure occurs and what the main sources of exposure are.

4. Control measures
   • If you know the main sources, effective measures to control these sources can be advised

5. Evaluation
   • With the same (calibrated) sensors the effect of the control measures can easily be visualised
THANK YOU
FOR YOUR ATTENTION

Check also our vision:
Virtual Occupational Hygiene Assistant
(www.tno/VOHA)