Field test evaluation of instrumental odour monitoring systems with a novel in-situ calibration approach

Practical evaluation of the CEN/TC 264/WG 41 method

9th IWA ODOURS & VOC/AIR EMISSIONS CONFERENCE

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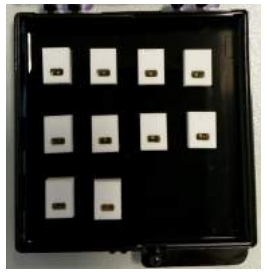
3S – Sensors, Signal Processing Systems GmbH

Company Overview

est. 2006
30 employees

- Experts in gas measurement
  - Leakage detection and odour assessment for industry and production
  - Indoor and outdoor air quality monitoring
  - Development of white label products: “Gas sensing solutions”
- Production and calibration of own and OEM products



Project context

IOMS development and field tests

- SEPEG
  - Sensor networks for objectified odour perception
  - Funded by the German Federal Ministry of Education and Research (FKZ 01IS1
  - Partners: 3S, Saarland University, Olfasense
- Goals
  - Development of a sensor system for odours that is suitable for calibration
    ⇒ IOMS = instrumental odour monitoring system
  - Development and test of calibration strategies
- Field test sites
  - Industrial site
    → Odour impact monitoring in nearby residential area (8 devices)
  - Wastewater treatment plant
    → On-site monitoring of odour occurre es)

EnvironmentalCheckerOutdoor (ECO)

IOMS development and field tests

- Robust enclosures for outdoors and public sites
- Pumped sampling with gas path switching
  - e.g. ambient / calibration / zero reference
  - e.g. A / B / zero reference (filter monitoring)
- Modular concept for
  - Metal oxide sensors (VOCs, H_2, CO, …)
  - PID (TVOC)
  - EC cells (NH_3, H_2S, NO_2, O_3, …)
  - ext: PM1.0/2.5/10, CO_2, rH, T, p
- Real-time online monitoring,
  data transport via LTE or ethernet,
  incl. geoposition
- Connectivity for local weather station
- UPS integration (solar, streetlight)

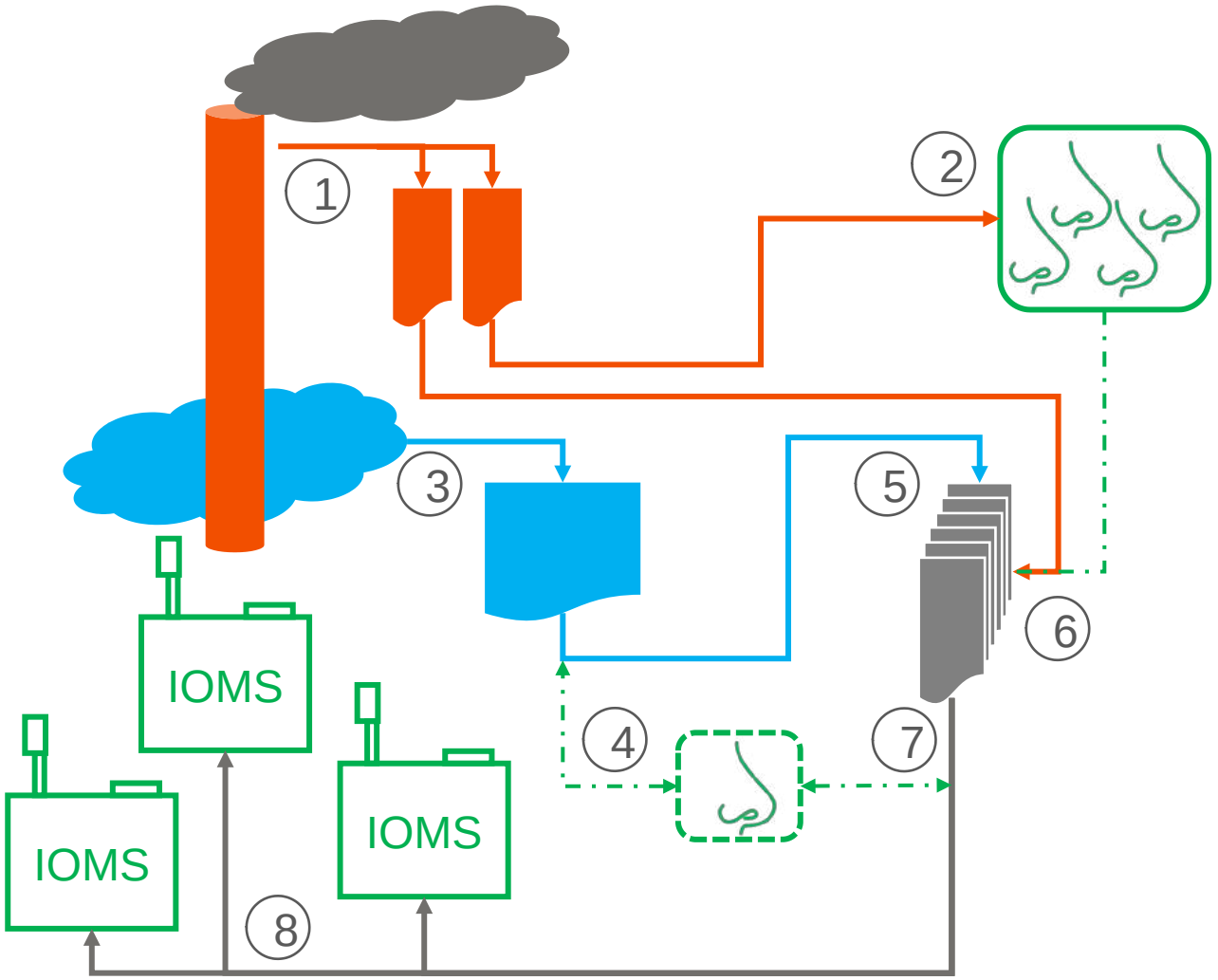
Calibration for training and validation

Field evaluation of calibration strategy

- CEN/TC 264/WG 41 aims at
  - Standard for **validation** of technical odour monitoring systems
    ⇒ Term IOMS = instrumental odour monitoring system
  - Use cases: Absence/Presence, identification, quantification
  - Prepared (diluted) source samples, allowing for predictable “occurrence” of target odours
- Manufacturer’s claim
  - Form confidence level and confidence interval
  - Basis for validation: Representative set of sample pairs (absence / presence)
  - Minimum requirement: 8 (9) pairs → Evaluation using Chebychev’s inequality
- Consequence for IOMS manufacturers
  - No **training** methods or requirements are given → Mfg’s responsibility, black-box-approach
  - General idea: Similar calibration rules for training and validation allow for comparability

Calibration strategy

Field evaluation of calibration strategy



1. Source sampling
2. Olfactometry (source odour concentration)
3. Background sampling
4. Direct evaluation (absence of target odour)
5. Splitting into *n* secondary sample bags
6. Injection of pre-calculated source sample volume into *n-1* secondary sample bags
7. Direct evaluation (presence of target odour)
8. Application to IOMSs

Calibration timetable

Field evaluation of calibration strategy

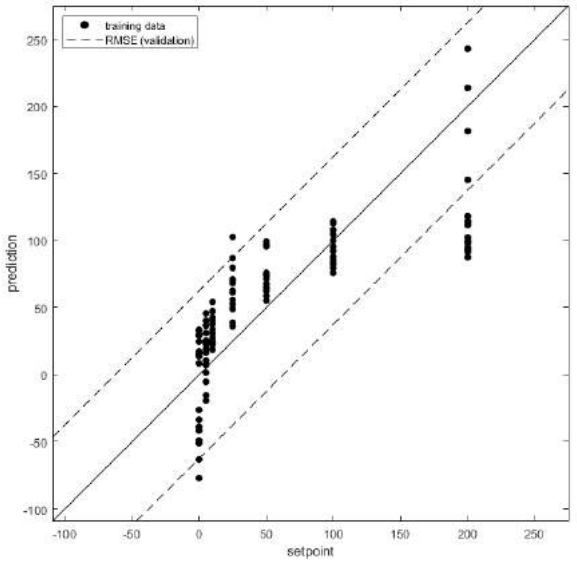
- Dilution series per source sample
  - 0, 5, (10), 25, 50, 100, (200) OU_E/m^3
- Two teams in offset shifts
  - Sampling and sample preparation
  - Application to IOMSs
- Throughput per day
  - 3 sample sets for 8-device-installation
  - 6 sample sets for 4-device-installation

Uhrzeit	Sample 1		Sample 2		Sample 3	
08:00	Source Sampling					
08:30	Background Sampling	Olfactometry of source sample				
09:00						
09:30	Dilution and direct evaluation of diluted samples					
10:00						
10:30	Application of diluted samples. Incl. Transport and waiting times, concurrent work in two groups		Source Sampling			
11:00			Background Sampling	Olfactometry of source sample		
11:30						
12:00			Dilution and direct evaluation of diluted samples			
12:30						
13:00			Application of diluted samples. Incl. Transport and waiting times, concurrent work in two groups			
13:30					Source Sampling	
14:00					Background Sampling	Olfactometry of source sample
14:30						
15:00					Dilution and direct evaluation of diluted samples	
15:30						
16:00					Application of diluted samples. Incl. Transport and waiting times, concurrent work in two groups	
16:30						
17:00						
17:30						
18:00						

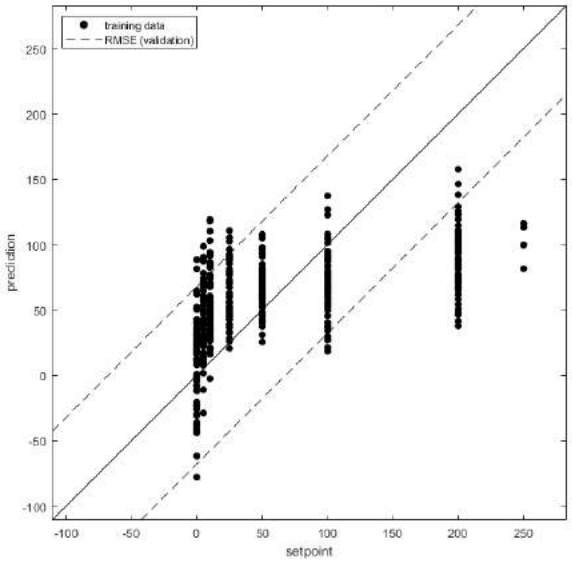
Results

From a calibration point of view

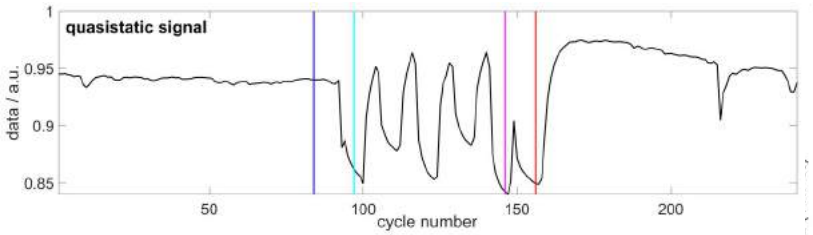
- Odour prediction
  - Training works better for industrial emission than for waste water (less source variation)
  - Validation result x = 15,5 @ α = 30 % (Dynamic olfactometry: x = 4 @ α = 5 %)
  - Comparability with grid inspection challenging for impact site monitoring (more background variation)
- Bag sampling and preparation method
  - Time consuming and expensive
  - Problem with sample bag zero-offset found, not solved yet
- Calibratable sensor system available with corresponding infrastructure

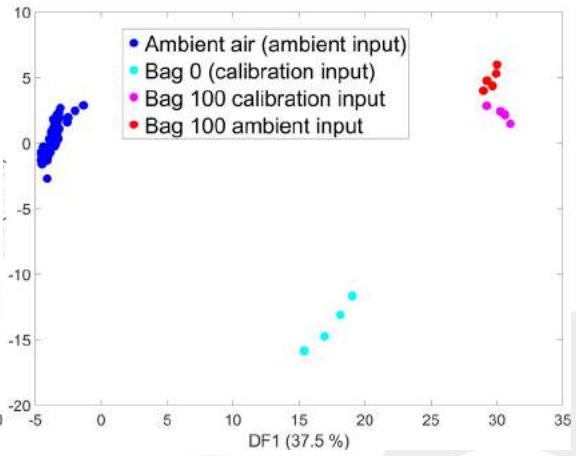


Industrial emission



Wastewater





Outlook

Streamlining IOMS commercialisation

- Revisiting the sample bag method
  - How to deal with strong background variation?
  - How to deal with zero offset in sample preparation?
  - Which role plays comparability to grid inspection?
- Consequences for manufacturers
  - Training method and effort have to be aligned to validation standard
    - Additional data needed for training, more than for evaluation (cost!)
    - Pre-training “out of the box” aka factory calibration
    - Reduction to sure-fire applications? (Emission + dispersion instead of impact site?)
  - Cost model for training and validation
    - Three campaigns about as expensive as a one-year EN 16841-1 grid inspection!
    - Only feasible for customers with own olfactometry capacity?

Thanks for your attention

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