Background

- Included in the REACH Guidance
- Applicable for exposure to dust, vapour, mist, and fumes
- Co-development with industry and member states
  - CEFIC, Shell, GSK, Eurometaux
  - HSE, Dutch government
- ART concept published in 9 peer reviewed papers
Exposure assessment is an ART and a science!

- Use of ART is not just pushing buttons
  Know what you are doing and why
- General concept
- Mechanistic model
- Percentiles and confidence limits
- Bayesian update & exposure database

Making full use of information

Uncertainty

Model + Data → Updated estimate

BDA
ART approach

- Exposure database, with contextual information
- Similarity module to select data for risk assessment
- Bayesian process to combine data and model output
- Exposure estimates for risk assessment

Equations:

\[ C_i = (C_{ih} + C_{if}) \cdot RPE \]
\[ C_{ih} = (E_{ih} \cdot H_{ih} \cdot LC_{ih} \cdot P_{ih} + Su_{ih}) \cdot P_{ih} \]
\[ C_{if} = (E_{if} \cdot H_{if} \cdot LC_{if} \cdot Seg_{if} + Su_{if}) \cdot D_{if} \cdot Sep_{if} \]

9 Modifying Factors (MF):
- Intrinsic emission potential (E)
- Activity emission potential (H)
- Local controls (LC)
- Separation (Sep)
- Segregation (Seg)
- Surface contamination (Su)
- Dilution (D)
- Personal behavior (P)
- RPE
Hierarchical structuring

Modifying Factor 1 → Modifying Factor 2 → Modifying Factor 3

Underlying determinants

Substance Emission Potential (dustiness)

<table>
<thead>
<tr>
<th>Category</th>
<th>Relative weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm granule</td>
<td>0.01</td>
</tr>
<tr>
<td>Granule</td>
<td>0.03</td>
</tr>
<tr>
<td>Coarse dust</td>
<td>0.1</td>
</tr>
<tr>
<td>Fine dust</td>
<td>0.3</td>
</tr>
<tr>
<td>Extremely fine dust</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Activity Emission Potential

Select Activity Class

- Spray application of liquids
- Activities with baths, contaminated objects or spreading liquids
- Activities with spray tools
- Fracturing and abrasion of solid objects
- Abrasive blasting
- Burns
- Dischargeting
- Hot solid handling
- Falls
- Chemical granules
- Leigh solid objects
- Burning of solids

- Hot / molten metal
- Solid objects
- Liquids
- Powders

- Corporate story

- Routine transfer
  - Careful transfer: involves workers showing attention to potential danger, error or harm and carrying out the activity in a very exact and thorough (or cautious) manner e.g. careful weighing in laboratory

- Transferring more than 1000 kg/minute (e.g. large scale transfer with big bags)
- Transferring 100 - 1000 kg/minute
- Transferring 10 - 100 kg/minute
- Transferring 1 - 10 kg/minute
- Transferring 0.1 - 1 kg/minute
- Transferring 10 - 100 gram/minute
- Transferring less than 10 gram/minute (e.g. very small scale weighing, fine adjustments) and scooping in laboratory

- Drop height > 0.5 m
- Drop height < 0.5 m or transfer using x gia
**local controls**

- No localized controls
- Suppression techniques
  - Wetting at the point of release
  - Knockdown suppression
- Containment (non-extracted)
- Local ventilation systems
  - Receiving hoods
  - Canopy hoods (hot processes)
  - Other receiving hoods
  - Capturing hoods
    - Fixed
    - Movable
  - On-tool (integrated) extraction
  - Enclosing hoods
  - Glove box
  - Fume cupboard
  - LEV systems with partial enclosure (no front cover)

**Dispersion**

- Indoor
- Outdoor
- Spray booth
Calibration with measurements

- Using multiple sources
  - Also including measurements in the low range
- Only good quality data: N~2,500
- Quantification in units (mg/m³)
- Provides model uncertainty
- Separate predictions for:
  - Dust
  - Vapour
  - Mist
ART Validation: Dust exposure
**ART - output**

Explicit treatment of variability and uncertainty
- **Percentile of distribution**
- **Uncertainty of estimate**

- Variability
  - 90th, 75th, 50th percentile

- Bayesian update
  - **Uncertainty**

- Inter-quartile: 80 %, 90 %, 95 % CI

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**Bayesian model...**

- Bayesian techniques allow for different types of information to be integrated in a theoretically rigorous way via probability theory.
Bayesian model...

- Bayes approach takes account of the relative strength of the different information sources
- Bayesian module is integrated in ART to update model estimate with user’s own data

The idea of Bayesian Update
ART prediction:  
GM: 0.32 mg/m³  
0.17-0.62 mg/m³  
Outcome mechanistic model: scooping

ART prediction:  
GM: 0.32 mg/m³  
0.21-0.52 mg/m³  
Outcome mechanistic model: scooping + bayesian update 3 observations 1 worker
**ART prediction:**
- GM: 0.32 mg/m³
- 0.23-0.47 mg/m³

**Outcome mechanistic model:** scooping + bayesian update 20 observations 1 worker

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**ART prediction:**
- GM: 0.32 mg/m³
- 0.23-0.44 mg/m³

**Outcome mechanistic model:** scooping + bayesian update 20 observations 20 workers
ART prediction:
GM: 0.32 mg/m³
0.27-0.38 mg/m³
Outcome mechanistic model: scooping + bayesian
update 20 observations 20 workers, 20 companies

ART prediction:
GM: 0.32 mg/m³
0.25-0.41 mg/m³
Outcome mechanistic model: scooping + bayesian
update 20 observations 20 workers, 20 companies,
more variability in dataset
ART version 1.5...

- ART v 1.0:
  - Facility to upload own exposure data in simple spreadsheet format

- ART v 1.5:
  - Exposure database is implemented in the ART system
  - Upload own data but also select measurement series from exposure database using simple search algorithm

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