TIMED-RELATED DECAY IN VOC EMISSIONS FROM A HIGH PERFORMANCE IT PRODUCT:

IMPACT OF DECAY ON THE QUANTITATIVE ASSESSMENT OF POTENTIAL RISKS ASSOCIATED WITH PRODUCT EMISSIONS

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HISTORY

- **Product stewardship program initiated 1989**
  - 18 months first test
  - 43 new products tested per year
  - > 300 products tested to date

- **Chambers**
  - 30 L, 667 L, 101 m³, 254 m³
  - Tedlar® - volume determination; permeation
HISTORY

Small Tedlar bag
HISTORY

30 L Chamber
HISTORY

667 L Chamber
HISTORY

101 m3 Chamber
HISTORY

254 m$^3$ Chamber
HISTORY

- All IBM Products Qualified
  - Printers, servers, PCs, monitors, storage, kiosks

- Risk Assessments
  - Chemical emission rates measured in chamber
  - Determine compliance with internal & external standards
  - OSHA, ACGIH, Prop 65, cancer, chronic, acute, developmental effects
Finite amount of residual VOCs

Aim of study to quantitate decay

Procure high-end server for 120 days
METHODS

- **Chamber methods:**
METHODS

- Chamber methods (cont’d.):
  - Blue Angel: “Test Meth. For the Deter. Of Emiss. From Hardcopy Devices with respect to awarding the Environ. Label for Office Devices according to RAL-UZ 122; 2006 (http://www.blauer-engel.de/englisch)
METHODS

- **Air Sampling Methods for VOCs, aldehydes, O₃**
  - VOCs: U.S. EPA TO-1; Tenax TA®
  - Aldehydes: U.S. EPA TO-11A; SG + DNPH w/ O₃ denuder
  - Dasibi 1008 AH O₃ monitor – UV
METHODS

- Chamber Description
  - 101 m³
  - stainless steel
  - filtered supply air
  - digital recorders
  - samples collected in exhaust duct
  - SF₆ verify ventilation rate
  - Stored in 254 m³ chamber between tests
METHODS

- **Test Regimen**
  - Clean chamber; empty chamber background samples
  - Day 1: 0.5, 1, 2, 4, 8 hr.
  - Day 31, 65, 94 and 120
  - Triplicate Tenax TA® samples: 1, 2, 4 L
  - Single aldehyde samples
  - Supply air samples during testing
  - Field blanks & media blanks
METHODS

- Risk Assessment Methodology
- NAS 4-step framework (1983):
  - Hazard Identification
  - Dose-response Assessment
  - Exposure Assessment
  - Risk Characterization
METHODS

- **Chronic RA Exposure Assessment**
  - Assumes constant ER w/o decay (conservative)
  - Product end-of-life = ED

\[
ADEL_{nc} = \frac{RC \times ET \times EF \times ED}{AT}
\]

Where:
- \( ADEL_{nc} \) = Average Daily Exposure Level (µg/m\(^3\))
- \( RC \) = Average [room] (µg/m\(^3\))
- \( ET \) = Exposure time (hours / 24 hours)
- \( EF \) = Exposure frequency (days / 356 days)
- \( ED \) = Exposure duration (years = product life)
- \( AT \) = Averaging time (years)
Results

Chamber Temperature vs. Operating Day
8/19/03 - 12/15/03

Temperature, deg. F.

Operating Day
(Day 1 = August 19, 2003)
Results

Chamber Relative Humidity vs. Operating Day
8/19/03 - 12/15/03
Results

Chamber Static Pressure vs. Test Day
in. H2O
8/19/03 - 12/16/03

Static Pressure, in. H2O

Test Day

1 31 65 94 120
Results

Storage = 1.6 ACH
Results

Average Acetonitrile ER
ug/hr. vs. Day

ug/hr.

Day
Results

Average Benzaldehyde ER
ug/hr. vs. Day

Day

ug/hr.
Results

Average Ethylbenzene ug/hr. vs. Day
Results

**Average Formaldehyde ug/hr. vs. Day**

The graph shows the average formaldehyde concentration in ug/hr. over the course of different days. The concentration decreases significantly from day 1 to day 31, and then remains relatively stable until day 120.
Results

Average Styrene ug/hr. vs. Day

Day

ug/hr.

1 31 65 94 120

0 100 200 300 400 500 600
Results

Average Toluene ug/hr. vs. Day

Day

ug/hr.
## System VOC + Aldehyde Time-Decay Emission Rates (µg/hour)

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Day 1 ug/hr.</th>
<th>Day 31 ug/hr.</th>
<th>Day 65 ug/hr.</th>
<th>Day 94 ug/hr.</th>
<th>Day 120 ug/hr.</th>
<th>max. ug/hr.</th>
<th>min. ug/hr.</th>
<th>avg. ug/hr.</th>
<th>% decrease min. to max.</th>
<th>% decrease day 1 to day 120</th>
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<td>0</td>
<td>643</td>
<td>89</td>
<td>4420</td>
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<td>115</td>
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<td>451</td>
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<td>2557</td>
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<td>632</td>
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<td>88</td>
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</tbody>
</table>
Results

Revised Chronic Non-cancer RA Equation:

\[
\text{ADEL}_{nc} = \frac{(RC_1 \times ET \times EF \times P_1) + (RC_2 \times ET \times EF \times P_2)}{AT}
\]

Where:

- \( \text{ADEL}_{nc} \) = Average Daily Exposure Level (µg/m³)
- \( RC_1 \) = max. room concentration during initial decay period (years)
- \( ET \) = Exposure time (hours / 24 hours)
- \( EF \) = Exposure frequency (days / 365 days)
- \( P_1 \) = duration of initial decay period (years)
- \( RC_2 \) = room concentration at end of decay period (years)
- \( P_2 \) = duration of product lifetime minus initial decay period (years)
- \( AT \) = Averaging time (years)
Thank You!

Questions?